The Journal of Thoracic Surgery

VOL. 13 OCTOBER, 1944 No. 5

Original Communications

ARTERIOVENOUS FISTULA OF THE LUNG

A REPORT OF A PATIENT CURED BY PNEUMONECTOMY

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ARTERIOVENOUS fistula of the lung usually masquerades in a cyanotic young patient with clubbing of fingers and toes as congenital heart disease or polycythemia until either a tumor of the lung or a continuous murmur in the chest is finally discovered. This report is concerned with such a case.

Four cases of arteriovenous fistula of the lung have been reported by Rodes,[1] Smith and Horton,[2] Hepburn and Dauphinee,[3] and Goldman.[4] These have all been summarized in Goldman's article, in which he reported his case in detail. Hepburn and Dauphinee's patient had a successful pneumonectomy by Shenstone and Janes and a diagnosis of cavernous angioma was made on the removed lung. Subsequently, Janes[5] treated bilateral multiple cavernous hemangiomas of the lungs by local resection of the tumors. The patient made a rapid recovery. Our case, so far as we know, is the sixth to be reported and the third in which operation was successful.

CASE REPORT

J. P., aged 24 years, a single, white woman, was referred, March 15, 1943, by Dr. Ralph F. Palmer of Phoenix, Ariz., to one of us (J. C. J.) for resection of a tumor of the right lung.

History.—The patient was cyanotic from birth and intensely so until the age of 16; thereafter, she is believed to have become somewhat less cyanotic. At birth and until the age of sixteen years, a soft, blowing,

Read at the Twenty-Fifth Annual Meeting of the American Association for Thoracic Surgery, Chicago, Ill., May 5 and 6, 1944.

basal systolic murmur without transmission was heard. Clubbing of the fingers began at the age of 9 years and progressively increased until 16, then remained stationary. She was restricted until that time, but was subsequently quite active without symptoms. One and one-half years before coming to us she was examined by an internist, and for the first time, an intrathoracic mass was seen by roentgenogram. On a presumptive diagnosis of tumor a course of radiation therapy was given, but it affected neither the mass nor the cyanosis. At that time polycythemia was noted and thought to be primary. The red blood cell count had ranged between 6.5 and 7.5 millions, with a hemoglobin of 130 per cent, for the last one and one-half years. There had been no abnormal white cells and there was no response to venesection done some time ago. She had been working steadily as a stenographer and leading a normal life.

Physical Examination.—The patient was well developed and nourished, of a slender build. She looked well and was a very handsome young woman. The hair, skin, and eyes were normal. The conjunctivae and mucous membranes were intensely cyanotic. The carotid pulsations were forceful and the jugular veins were not distended. The thorax was average in size and symmetrical. The heart was normal in size, with a moderate apex impulse and no thrill. There was slight sinus arrhythmia at a rate of 96 per minute. The sounds were normal with no accentuation of P_2. Murmurs were not heard. The lungs were clear. Over the right breast and just beneath it there was a moderately loud, rough, roaring murmur, probably continuous, of maximal intensity at the end of systole and the beginning of diastole. It was loudest at the end of inspiration and almost disappeared on expiration. There was no thrill. The pulses were normal. The blood pressure in the right arm was 112/94, in the left arm 110/92. The abdomen was negative. There was marked clubbing of the fingers and toes.

Fluoroscopy.—The right hilum was increased in density and a pulsating vessel radiated from the right upper hilum to a round mass (8 or 10 cm. diameter) just above the right diaphragm anteriorly.

Electrocardiogram showed a tendency to right axis deviation.

Urinalysis, blood Wassermann and Kahn tests were negative, and there was no sputum.

Hematology (as reported by Dr. Madeleine Fallon).—Hemoglobin 130 per cent; red cell count, 7,080,000; white cell count, 7,350. Differential: Neutrophiles, 63 per cent, lymphocytes, 25 per cent; monocytes, 12 per cent. Platelets were normal. The normal leucocyte count, the normal number of platelets, and the absence of changes in the blood, such as basophilic stippling and immaturity in the white cells, indicated that this was a secondary and symptomatic polycythemia.

A provisional diagnosis of arteriovenous aneurysm of the right lung was made on the history of cyanosis since birth, the persistent secondary or symptomatic polycythemia, the presence of a continuous murmur over the tumor mass in the right lung, clubbing of the fingers, and a normal heart. She was advised to return for hospitalization and further study.

April 8, 1943, she was admitted to the Hospital of the Good Samaritan and further roentgen studies were made. Roentgenograms and planigrams were interpreted by Dr. Richard Taylor (Figs. 1, 2*A*, 2*B*, 2*C*, 2*D*, and 2*E*). A series of body section radiographs was made from 3 to 16 cm. through the right lung. These demonstrate that the vessels to the right upper and to at least part of the right lower lobe were separate from those entering the large abnormal masses noted in the plain radiographs made elsewhere (Fig. 1). These masses appeared to be vascular in character and there was some indication that they were comprised largely of dilated branches of the pulmonary artery going to the right middle lobe. In the more anterior radiographs, a calcification made its appearance in the rounded lower mass. The mass appeared to be separate from the diaphragm. Fluoroscopically, the whole thing seemed to pulsate. Roentgenograms of the fingers revealed no bony changes. Fearing the dangers of thrombosis in patients with polycythemia we did not inject diodrast intranvenously.

Further studies revealed the venous pressure to be 6 cm. of water. The plasma volume was normal but the whole blood volume was 170 per cent of normal.

Because the continuous murmur over the mass was greatly increased on full inspiration and almost disappeared on full expiration, it appeared that it might be of some clinical value to institute a right pneumothorax in an attempt to collapse the arteriovenous communication and maintain it for several months with the expectation that there might be some change in the cyanosis, polycythemia, and blood volume. Pneumothorax was begun April 12, 1943, (Figs. 3 and 4) and the patient was discharged home one week later to continue with pneumothorax under the care of her physician.

Sept. 18, 1943, she returned to the hospital after five months of pneumothorax therapy. Because of dyspnea and mediastinal herniation it had been impossible to produce sufficient intrapleural pressure to collapse the fistula completely. There was no change in the blood counts, blood volume, or cyanosis. It was of interest that she had noted transverse ridges on the fingernails and toenails which had appeared coincident with each pneumothorax refill. It appeared clear that an arteriovenous fistula of the right lung was present and that, despite failure of the mass to collapse completely, surgery was indicated.

Operation, September 20, 1943 (J. C. J.).— Under cyclopropane anesthesia by Dr. Lawrence Lee, a curved inframammary incision was

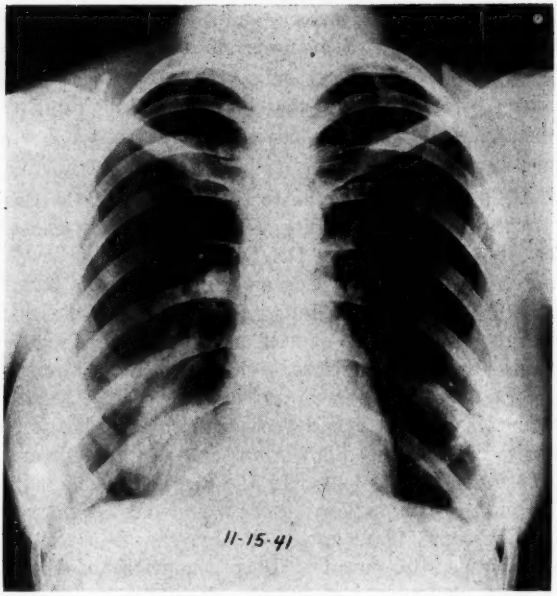

Fig. 1.—Anteroposterior roentgenogram revealing a multilobulated tumor extending downward from the right hilum.

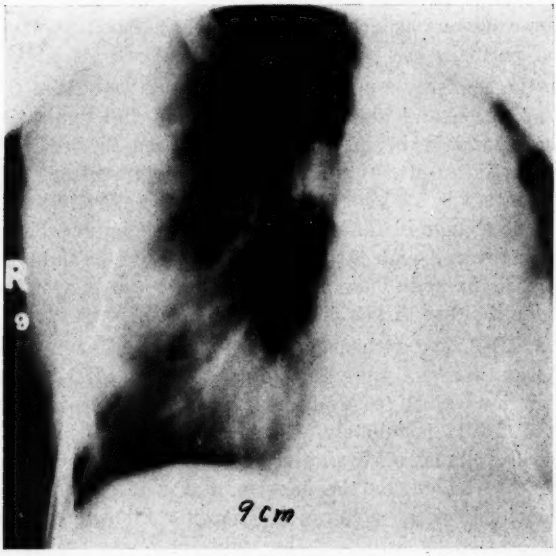

Fig. 2A.

Figs. 2*A*, 2*B*, 2*C*, 2*D*, 2*E*.—Planigrams at 9, 10, 12, 13, and 15 cm. levels, respectively, demonstrate a multilobulated tumor mass extending from branches of the right pulmonary artery. The more anterior radiographs (*D* and *E*) reveal an irregular calcific deposit in the lower rounded mass.

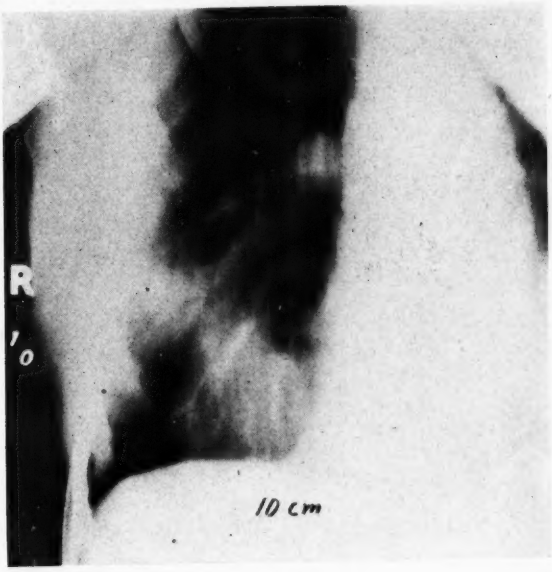

Fig. 2B.

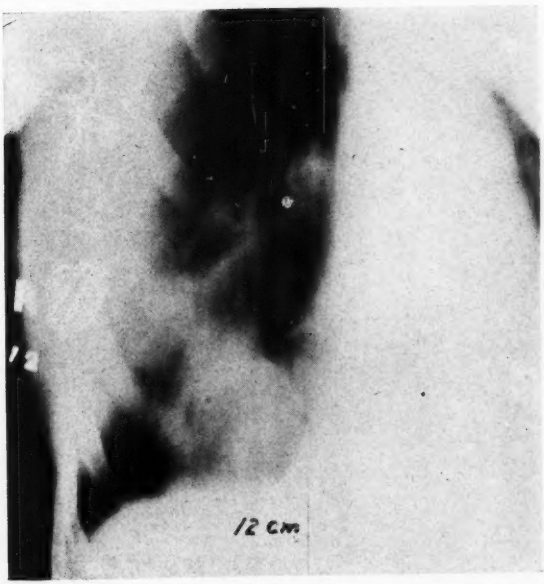

Fig. 2C.

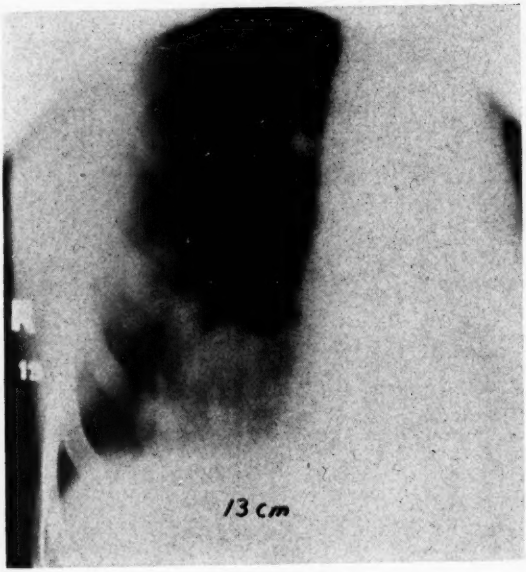

Fig. 2*D*.

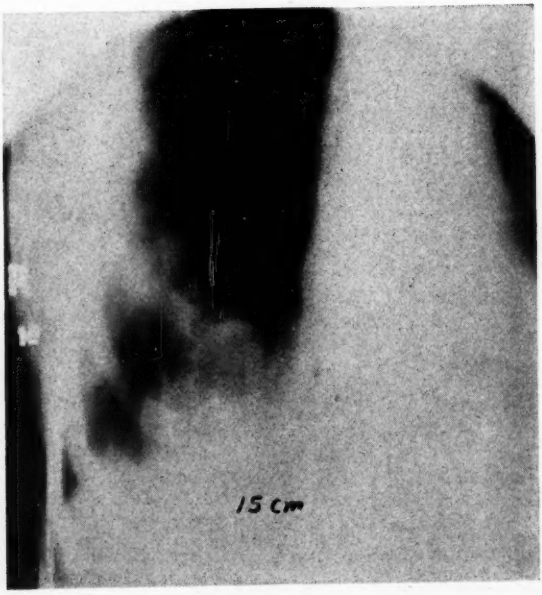

Fig. 2*E*.

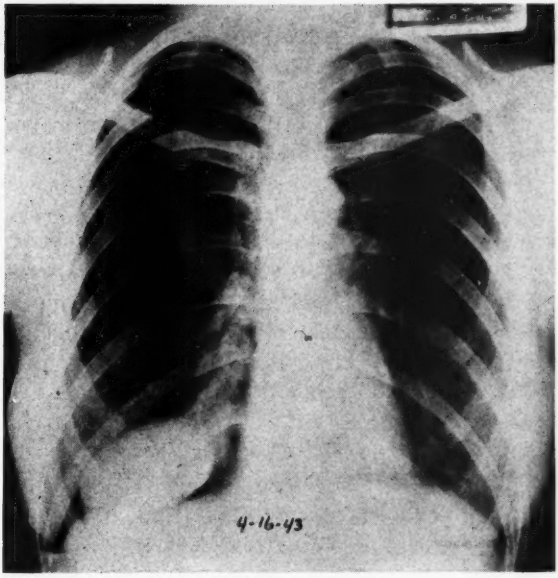

Fig. 3.

Figs. 3 and 4.—Posteroanterior and oblique roentgenograms after establishing right pneumothorax accentuate the lower tumor mass in the anterior position with apparent disappearance or collapse of other portions of the mass.

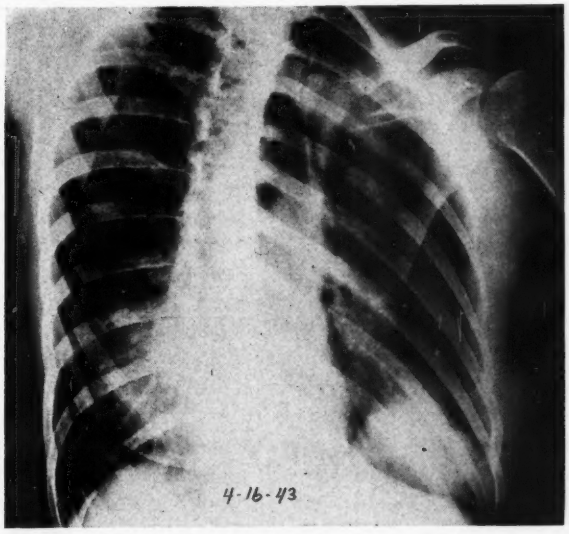

Fig. 4.

made extending from the third intercostal space anteriorly, under the right breast and upward and laterally to the third rib in the midaxilla. The pectoral muscles and breast were reflected upward and the pleural cavity opened by incising through the third intercostal muscles and pleura from the cartilages anteriorly to the posterior axillary line. Rib spreaders were placed and the ribs spread widely without resection or fracture. The right lung was 60 per cent collapsed by pre-existing pneumothorax. There was no semblance of a middle lobe and no adhesions. Over the lower half of the anterior surface of the upper lobe was a large number of blue distended varicosities. Attached to and suspended from the anterior and inferior aspects of the upper lobe (roughly corresponding to where the middle lobe should normally be located) a structure much the same as a distended gall bladder would hang from the liver, a reddish-blue pulsating mass the size of a lemon with a paper-thin wall, was seen to rest freely on the diaphragm. The right lower lobe appeared normal. What appeared to be the right pulmonary artery was large and dilated (3.5 cm. diameter). No superior pulmonary vein was seen, either at operation or in the specimen afterward. The inferior pulmonary vein was normal. Linen tapes were passed around the pulmonary artery and the inferior pulmonary vein. When the pulmonary artery was occluded by the tape, the pulsation in the tumor mass in the right upper lobe ceased, but there was no great change in its size. On occluding the inferior pulmonary vein the pulsation in the mass continued, the mass became larger and more distended, and the superficial varicosities over the surface of the upper lobe likewise became more prominent. It was obvious then, that the tumor mass had a direct communication from the pulmonary artery to the pulmonary vein and that since the inferior pulmonary vein emptied this vascular sac it was necessary to sacrifice the entire right lung. A right total pneumonectomy was done by dissection and individual ligation; first, the pulmonary artery was cut between transfixion sutures, then the inferior pulmonary vein likewise dealt with; finally the lung was amputated distal to a clamp applied to the right main bronchus. The right main bronchus was closed with eight over-end single stainless steel, 35 gauge wire sutures tied after the clamp was removed. The mediastinal pleura was closed after thorough irrigation of the stump and the pleural cavity with saline solution and after 5 Gm. of sulfanilamide crystals were sprinkled over the bronchial stump. The ribs were brought together with pericostal sutures and the chest wall was closed in layers without drainage. No blood transfusion was given because of the polycythemia, but a slow venoclysis of physiologic saline (1,000 c.c.) was administered during the surgery. She left the operation table in excellent condition.

Postoperative Course.—It was amazing to see the disappearance of the cyanosis in a matter of a few hours. She was given oxygen by

TABLE I

DATE	HB. (%)	R.B.C.	W.B.C.
3/15/43	130	7.08	7,350
9/19/43	130	7.11	5,700
9/20/43	104	5.90	(P.M. of surg.)
9/22/43	85	5.20	(2nd P.O. day)
9/24/43	73	4.10	(4th P.O. day)
10/ 8/43	86	5.30	(18th P.O. day)
1/10/44	80	4.04	9,350

nasal catheter for four days (routine procedure) although at no time was she cyanotic or dyspneic. She had a normal temperature on the fourth day and it remained so except for a mild gastrointestinal upset on the fourteenth postoperative day with nausea, vomiting, and diarrhea. This responded promptly to the usual measures and intravenous fluid. The wound healed per primam. She was ambulatory on the twenty-first day and was discharged home on the twenty-eighth postoperative day. Table I shows the progress of the blood picture before and after surgery.

Fig. 5.—Roentgenogram of specimen (right lung) after injection of opaque solution into the inferior pulmonary vein. The aneurysmal sac filled promptly as did the branches of the pulmonary artery demonstrating the fistulous communication.

Pathologic Report.—The specimen (Figs. 5, 6, and 7) was the right lung which had been amputated just above the upper lobe bronchus. There were two lobes, an upper and lower, with a distinct fissure. There was no middle lobe. The lower lobe appeared normal. The inferior pulmonary vein was of normal caliber. The right upper lobe had many blue, thin-walled varicosities over its anterior surface and

there appeared to be a very thin-walled sac filled with dark blood projecting from the lower aspect of the upper lobe at the site corresponding to where the middle lobe should be. This sac was 7 by 7 by 8 cm. and appeared to be an extension downward of the pulmonary artery. On the anterior inferior aspect of the sac there was a calcified plaque 2 by 2 cm. There were also two small calcific deposits in the lingula of the right upper lobe just above the sac. The pulmonary artery at its opening just above the upper lobe bronchus was 4 cm. in diameter. It was found to be widely dilated and it extended downward to the lower tip of the upper lobe, the diameter of this vessel

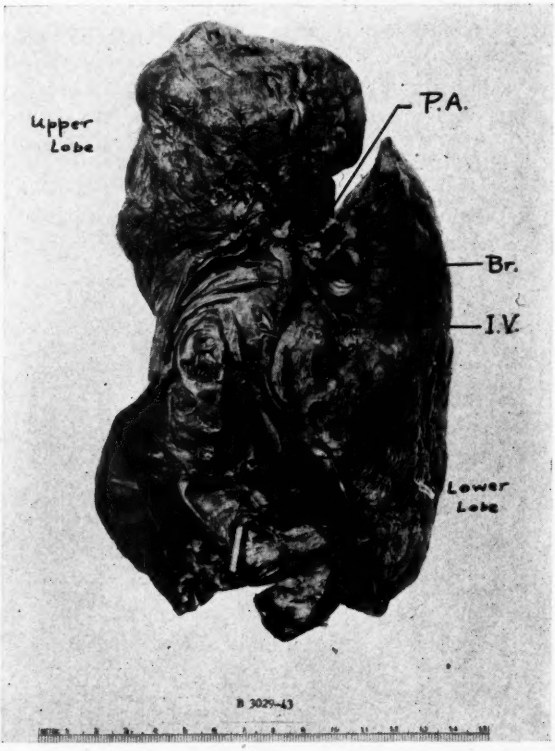

Fig. 6.—Photograph of mediastinal aspect of right lung. The pulmonary artery (*P.A.*) empties into a large, thin-walled sac which in turn communicates with another sac on the lateral aspect (see Fig. 7) through an 8 mm. fistulous opening through which an applicator stick has been passed. The inferior pulmonary vein (*I.V.*) is seen just below the main bronchus (*Br.*).

being 3 cm. at its upper extremity and 2 cm. at its lower extremity and finally ending in a bulbous tip 3 cm. in diameter where there was an opening 8 mm. in diameter which extended downward terminating in the large sac previously described. When the large, globular sac was opened it was found to be full of unclotted blood and extended

up in the lung parenchyma to a level of about the upper lobe bronchus and there ended blindly. In the larger, more anteromesially located sac which was seen to extend up in the lung parenchyma, there were multiple valvelike openings, some of which seemed to end in blind sacs; others communicated with the superficial varicosities, and others apparently communicated with the branches of the inferior pulmonary vein. No superior pulmonary vein was found in the specimen. The inferior pulmonary vein when injected with barium was found to communicate with the sac, for the barium passed back up through the branches of the vein and finally ended in the large aneurysmal sac.

Fig. 7.—Photograph of lateral aspect of specimen showing stick passing from mesial inferior sac to another lateral sac in which are seen multiple small openings through which it presumably emptied itself.

One got the impression that in this specimen there was a large distended and dilated pulmonary artery which communicated at its inferior extremity with another, more anteriorly located, thin-walled aneurysmal sac which appeared to end blindly in about the mid-upper lobe but which drained through and emptied back into the lung parenchyma through multiple openings and eventually emptied into the inferior pulmonary vein. Diagnosis was arteriovenous fistula of the lung.

Fig. 8.—Photograph of patient four months after operation. The inframammary scar is concealed by the right breast and there is some retraction of the right thorax; otherwise there is no deformity.

Fig. 9.—Photograph of hands four months after operation reveals the clubbing had receded about 50 per cent or more.

Jan. 10, 1944, almost four months after operation, the patient returned to the office for checkup. She reported that she was well, leading an active life, dancing, and was free of breathlessness. At the end of an active day sometimes she felt a "tiredness" in the right shoulder. Cyanosis had not been evident and she had noted a marked recession of the clubbing of the fingers and toes. She looked perfectly well. (See Fig. 8.) Cyanosis and dyspnea were absent. The conjunctivae were of normal color. There was no jugular distention. The heart sounds were normal and no murmurs were heard. The right upper anterior chest was depressed; the right chest showed no respiratory movement, was flat to percussion, and the breath sounds were absent. The blood pressure was 110/70. The liver and spleen were not felt. Edema was absent. Clubbing, while present, was definitely less in degree (Fig. 9).

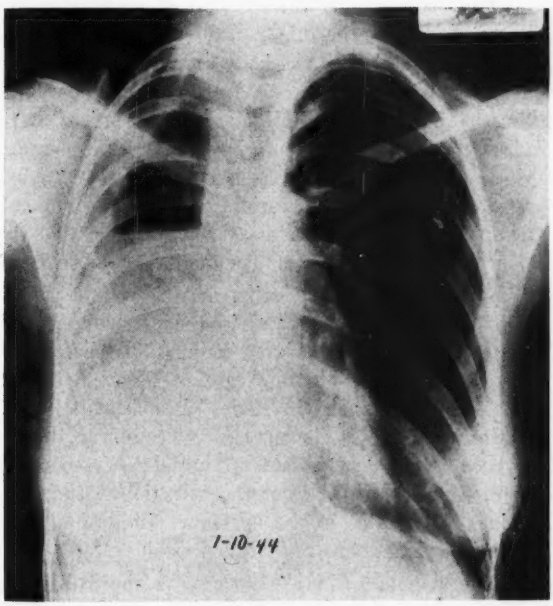

Fig. 10.—Roentgenogram of chest almost four months after operation showing thickened pleura with air above a fluid level at the first interspace.

Fluoroscopy showed a small, vertical vigorously pulsating heart, without conus fullness. The right chest was almost filled with fluid above which there was air, with level which was easily movable (Fig. 10).

In March, 1944, the patient was married.

DISCUSSION

As pointed out by Goldman[4] all the reported cases present clinical features and a symptom complex so similar that it is possible to

describe a clinical syndrome which is unmistakably an arteriovenous shunt in the lung. Clubbing of the fingers and toes is always present. Polycythemia is a constant finding, its degree being in direct proportion to the size of the fistula. This is a secondary or symptomatic increase in red blood cells, with no increase in blood plasma, white blood cells, or platelets, and the blood volume may be increased to as much as 170 per cent, as in our case. It is distinguished also from true polycythemia by the absence of changes in the blood such as basophilic stippling and immaturity of the white blood cells. The oxygen unsaturation of the arterial blood is another constant finding. Goldman,[4] Hepburn and Dauphinee's[3] patients had an arterial oxygen saturation of 70 per cent. This test was not available in our case. The lack of any cardiac hypertrophy or pathology is due to the fact that the lesion is confined to the pulmonary circulation; this is an outstanding clinical feature. The presence over the tumor of a continuous murmur which is loudest at the end of systole and the beginning of diastole, and louder at the end of deep inspiration is of great aid in the diagnosis. Finally, of diagnostic importance is the finding of a chronic, nonprogressive pulmonary lesion which on ordinary roentgenograms appears as a solid mass, but which by planigrams is seen to be a branching mass and connected to the pulmonic arterial tree. The symptoms of headache, faintness, thickness of speech, ease of fatigue, and dyspnea on exertion, referred to by Goldman as common, were absent in our case.

Rationale for Surgery.—The question may reasonably be asked why surgery should be performed or advised in a young patient with arteriovenous fistula in the pulmonary circulation when the lesion has imposed no incapacitation as in our case. The fact that rupture of the fistula led to sudden death in Rodes' case has its counterpart in the extreme thinness of the sac in our case. Trauma to the chest would surely have been poorly withstood. Thromboses secondary to the polycythemia present a hazard. Bacterial infection of the fistula similar to that seen in such fistulas in the systemic circulation, although not reported to our knowledge, are probably possible.

Ideally, one would hope to be able to remove the fistula without disturbing the lung. Failing this, one would hope to sacrifice not more than a single lobe. In our case a total pneumonectomy was imperative because there was absence of the superior pulmonary vein and the upper lobe arteriovenous aneurysm was emptied through the inferior pulmonary vein. Experience with this case leads us to believe removal of the fistula without sacrificing at least one lobe is only occasionally to be accomplished.

SUMMARY

1. Arteriovenous fistula of lung produces a syndrome characterized by cyanosis, clubbing of fingers and toes, symptomatic polycythemia,

and symptoms of anoxemia, usually in a young patient with an obscure lung tumor and a normal heart. A continuous murmur may be heard over the tumor.

2. The treatment is resection of the fistula or pulmonary resection, either of the lobe or the entire lung.

3. The case of a patient with arteriovenous fistula of the right lung cured by pneumonectomy is reported in detail.

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DISCUSSION

DR. WILLIAM E. ADAMS, Chicago, Ill.—I enjoyed very much hearing this excellent presentation of Dr. Jones' case. The increasing number of reports of this condition speaks for its greater frequency than has been believed in the past.

In all probability a number of fistulas of the lung have gone undiagnosed and the patients have been treated for polycythemia vera. I would like to present the slides of a case which first came to our attention about one year ago.

(Slide 1.) The patient was a 24-year-old man who came for treatment of repeated attacks of epistaxis. He gave the history of having had clubbing of the fingers and toes and marked cyanosis for a period of about sixteen years or when he was about 8 years of age. He had worked on a farm until about one year before his admission and had not been really incapacitated by the lesion. He lost little weight, although he was relatively thin.

The other symptoms which he presented were few outside of having those changes which can be seen on his lips, hemangioma on both lips. The clubbing and cyanosis were as marked on the toes as on the fingers.

(Slide 2.) On examination, little could be found other than what was seen in the first picture. There was, as in Dr. Jones' case, no evidence of a thrill or murmur over the area in which the irregular opacity in the left lung mid-field can be seen. It is impossible to see also a very small opacity which was present in the right lung field. This picture is one taken on admission and is similar to the first which was made two years before admission. There were very marked changes in the lung and long bones of the arms and legs; marked sclerosis and periosteal new bone formation. This was evident even down in the metatarsus and phalanges of the feet.

(Slide 3.) On examination of the blood, as in Dr. Jones' case and all these cases, there was a marked increase in the hemoglobin and cellular content. You see here the blood volume is practically double, all of the increase being the cellular content. The hemoglobin was 23 Gm. and the red cell count 7,200,000.

(Slide 4.) The oxygen studies, as you notice, were very interesting. Although this man was markedly cyanotic he had 25.1 volumes per cent of oxygen in the arterial blood with a capacity of 35.5 volumes per cent. In other words, there was an enormous compensatory change. The diagnosis of the condition was made by

my associate, Dr. Thornton, on the basis of the marked clubbing, cyanosis, the x-ray shadow, and no evidence of cardiac disease.

A left pneumonectomy was done, and at the time no attempt was made to replace the blood loss which was about 2,000 c.c. Instead, it was replaced by plasma for we didn't know how much ill effect there would be by the sudden reduction in the blood volume. I won't go into all the details, but following operation there was an immediate fall in red cell count and hemoglobin content, and a restoration of the oxygen values to approximately normal. The patient made an uneventful recovery and has been working since. This operation was made one year ago last February.

DR. ROBERT M. JANES, Toronto, Canada.—Actually we have had only three cases. The first case (operation by Dr. Shenstone) was similar in every way to the case that Dr. Jones has reported except that there were such great leashes of vessels about the hilum that a pneumonectomy by the tourniquet technique was necessary. A brief attempt at dissection made it obvious that if this method were followed the result would be a fatal hemorrhage. Fortunately, healing by primary union occurred and no bronchial fistula developed. The patient has since had two children.

The third patient had a single lesion in the middle lobe and was treated successfully by a dissection lobectomy. It is the second case that I thought might be interesting to you, particularly as the pages of the *British Journal of Surgery,* in which it was reported recently, may not be accessible to many of our members. This patient was a young man 30 years of age, who had been well except that he had always been somewhat lacking in energy. Two years before I saw him, while in the reserve Army, he ran across the camp and suddenly coughed up a considerable quantity of blood. This was repeated twice in the succeeding weeks and he was discharged. The x-ray picture was said to be normal. There were no further symptoms until three weeks before I saw him, when after moderate exertion he again had a very severe hemoptysis (slide 1). The roentgenograms at that time were as you see. There was a large lesion in the right lung and one small one. There were two small lesions in the left lung. This case was an exact duplicate of Rodes' even to the presence of multiple small submucous hemangiomas on the lips. There were no blood changes. Oxygen saturation studies were, unfortunately, not done because of wartime shortages of staff. The right side was operated upon first. Upon opening the chest the diagnosis became obvious. Since the lesions were bilateral the problem presented was different.

It was decided to attempt local resections. The large lesion was about the size of a hen's egg. The vessels entering it, each about 4 or 5 mm. in diameter, were individually isolated and ligated. It was then easy to remove the tumor without bleeding. The smaller one was removed by simply placing clamps on either side of it and excising the tissue between them. The defects in the lung were oversewn. The patient recovered satisfactorily. Six months later the left chest was opened and local resections of the two lesions in the lower lobe carried out. He again made a good recovery and has remained well.

I should like to point out that the polycythemic changes may occur late in these patients. In our first patient we know that these changes were not present only a little more than one year before she was operated upon even though her symptoms dated back to when she was 12 years of age. Neither of the other patients had polycythemia. Since there is danger from hemorrhage the development of this condition should not be awaited.

I would suggest that we keep hemangiomas in mind as a possible explanation of serious pulmonary bleeding not otherwise explicable. I have operated upon one other patient for recurring massive hemorrhage from an upper lobe that was certainly going to prove fatal. The pathologists failed to discover the source of

bleeding. I am now convinced that they overlooked one of these lesions. I have recently seen a section of a hemangioma of a lung accidentally discovered in routine autopsy. Had the block for section not included it by mere chance, its presence would not have been suspected.

DR. I. A. BIGGER, Richmond, Va.—I would like to raise a question, but am not certain as to the advisability of the procedure I have in mind. It seems to me that in some of these cases ligation of the branch of the pulmonary artery to that lobe should be considered. I am, of course, fully aware of the inadvisability of ligation of the artery alone in arteriovenous fistulas involving peripheral vessels, but I believe this is a different problem. While there are communications between the bronchial arteries and the pulmonary veins, there are few collateral arterial channels, so proximal occlusion of the artery might cure the fistula.

DR. JOHN C. JONES, Los Angeles, Calif.—In answer to Dr. Bigger's question, this was a hugely dilated, thin pulmonary artery, and after we passed a tape around it, it seemed as though the tumor mass did not diminish in size after the tape was drawn taut in order to close off the blood supply passing through the pulmonary artery. I did not feel justified in trying to dissect out the branches of the pulmonary artery because the branches seemed almost as large or larger than the normal size of the average pulmonary artery. The fact that there was no superior pulmonary vein to be found and that the inferior pulmonary vein appeared to carry all the blood back to the left heart was even more important. These two considerations led me to believe that it would be better not to attempt local resection and perhaps get a hemorrhage which could be controlled easily, I grant you, because I had a tape around the artery at its origin. I feel satisfied in my own mind that I would rather sacrifice the lung than attempt to dissect out any of the branches or even to leave the lung in and ligate the pulmonary artery.

INDICATIONS FOR PERICARDIOTOMY WITH SPECIAL REFERENCE TO THE EXPOSURE OF AN INFECTED PATENT DUCTUS

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INJURIES of the heart and hemopericardium, suppurative and constrictive pericarditis, foreign bodies, and neoplasms comprise the roster of conditions for which pericardiotomy with or without drainage may be indicated. They can be termed the standard indications for the operation. It can be assumed that pericardiotomy has been employed for a variety of other purposes which are not referred to in the literature. Since pericardiotomy is to be regarded as safe and free from untoward sequelae the possible usefulness of the operation for conditions other than the standard ones is worthy of consideration. I shall describe such conditions encountered in my own experience and hope that others will join in broadening the indications for the procedure. In all the conditions which will be described, with the exception of the patent ductus, pericardiotomy was at least begun as an exploratory procedure. The description of each of the conditions will be accompanied by an illustrative case report.

1. *Exploration Within Pericardial Sac of Hilar-mediastinal Lymph Nodes.*—In a number of instances of carcinoma of the lung there was considerable doubt at exploratory thoracotomy as to the extent of hilar node involvement. This was particularly the case when the lung was broadly adherent posteriorly or when the tumor in the lung abutted on the posterior mediastinum. In either instance considerable dissection would be required to ascertain the presence and extent of lymph node involvement; this would be unnecessary if the lesion were inoperable. Pericardiotomy and exploration within the sac supplied the required information.

CASE REPORT

H. N., a man 60 years old, not a good operative risk, had a history chiefly of pulmonary infection and positive biopsy from the bronchus of the left lower lobe. Exploration was done through a liberal transthoracic incision. Both lobes, especially the lower, were broadly adherent posteriorly. There was a substantial mass in the superior portion of the lower lobe which appeared to be partly neoplasm and partly inflammatory and was adherent to the parietes behind the hilus. Inspection in front of the hilus revealed several small lymph nodes which

Read at the Twenty-fifth Annual Meeting of the American Association for Thoracic Surgery, Chicago, Ill., May 5 and 6, 1944.

were removed for biopsy. One was positive. Informative palpation of the posterior aspect of the hilus was not possible. The pericardium was incised freely and palpation within it revealed a series of obviously involved nodes at the hilus and in the mediastinum, rendering the lesion inoperable. The pericardium was not sutured, but would have been sutured if the lesion had been operable. The thoracic wound was closed. The postoperative course was uneventful.

2. *Decompression of Serous Pericardial Effusion. Exploration.*— Upon a number of occasions obvious accumulations of fluid within the pericardial sac are to be noted at thoracic operations performed for a variety of conditions. Whether or not they play any part in the presenting clinical picture usually does not come into question. However, in the following case pericardiotomy was performed because the accumulation of fluid apparently produced some measure of cardiac tamponade.

CASE REPORT

J. M., Jr., 24 years old, suffered from thoracic pain in the left side and unproductive cough for a year. Because of a clear left pleural effusion he was said to have been discharged from Military Service with the diagnosis of tuberculosis. A recent complaint was dyspnea and asthenia of three weeks' duration. Bronchoscopy revealed a stenosing lesion of the left upper lobe; biopsy suggested a malignant tumor. An exploratory left thoracotomy was performed. Soon after the chest was opened the blood pressure began to fall, the pulse to become small and rapid. An infiltrating tumor of the upper lobe intimately attached to or invading pericardium was noted. There were no involved anterior hilar nodes. The pericardium was tense and cardiac pulsations could scarcely be discerned. The pericardium was freely incised adjacent to the tumor and there was the escape under tension of a very considerable quantity of clear fluid. Immediately thereafter the pulse volume improved, the pulse rate slowed, and the blood pressure rose. Before incision of the pericardium it appeared doubtful if the patient's condition would permit of further investigation, to say nothing of eradication of the neoplasm. After drainage, the general condition was good enough to proceed, thus indicating that the clinical picture probably was due to a measure of cardiac tamponade which had been present for several weeks before operation and was presumably exaggerated by anesthesia. The further investigation in this case consisted of exploration through the widely opened pericardium. Posteriorly, neoplastic tissue (from which a specimen was removed and reported as anaplastic medullary carcinoma) was felt and visualized. It not only invaded the pericardium in this region but also appeared to invade the heart directly. The case was thus inoperable, the pericardium was left open, and the thoracic wound was closed. The postoperative course was uneventful and there was no

return of the picture suggestive of cardiac tamponade. He left the hospital about two weeks after operation and died several months later.

3. *Exploration to Determinate Extent of Invasion of Pericardium by Pulmonary Neoplasm. Partial Excision of Pericardium.*—A report has been made before the American Association for Thoracic Surgery concerning a peripherally invasive type of pulmonary cancer which also is usually characterized by limited and late (if any) regional lymph node involvement. Metastases are prone to occur via the blood stream. Thus, the local situation is favorable for eradication in such cases provided it is possible to excise beyond the region (such as diaphragm and thoracic wall) of peripheral invasion. In the following case the lesion appeared at first to be inoperable because of fixation at the mediastinum and invasion of the pericardium. Exploratory pericardiotomy revealed the extent of the invasion. Liberal sacrifice of the pericardium made possible an adequate excision of the tumor.

CASE REPORT

M. F. B., a man 50 years old, was admitted with a history of asthenia, weight loss, cough of six weeks' duration, and pain in the left upper chest of two weeks' duration. On percussion there was dullness behind the sternum extending to the left side. In the roentgenogram there was seen a large mass apparently in the upper lobe and attached anteriorly. Bronchoscopy was negative. The operation was performed June 30, 1942. Extending from the anterior portion of the upper lobe was a tumor which occupied the anterior mediastinum and was tightly wedged in place. Adhesions were separated but the tumor remained immobile. In order to attempt to ascertain the possibility of removal and the extent, if any, of invasion of the pericardium, an incision was made through the parietal pericardium above the tumor. The tumor was found to invade broadly the parietal pericardium, bulging into the sac and compressing the heart. However, there was no invasion beyond the parietal pericardium. The latter was incised around the tumor sacrificing a section about three inches in each diameter. The tumor was thereby released and it was removed together with about one-half of the upper lobe by the tourniquet technique. (Microscopic report: squamous-cell carcinoma.) In order to cover the large pericardial defect the pulmonary tissue adjacent to the stump was approximated to mediastinal tissues medial to and above the pericardial defect.

It now is almost two years since operation. The patient is in good condition, symptom-free, and pursues an active occupation.

4. *Adhesive Pericarditis With Slight External Evidence. Exploratory Pericardiotomy Followed by Partial Pericardiectomy.*—In addition to the classical forms of constrictive pericarditis there are cases with similar clinical manifestations in which the constricting factor is not evident. To these I have attached the term "restrictive peri-

carditis." The point to be made here is that these may not be identified at operation by an inspection of the external surface of the pericardium. An exploratory incision of the pericardium is indicated. It can be added that the diagnosis of constrictive pericarditis is not always easy and that a symptom complex which appears to be more or less characteristic may be due to lesions quite unrelated to pericardial disease. Thus, there was an instance in which I explored the pericardial sac and found it to be free from abnormality. Subsequently the case came under the observation of White in Boston. The clinical picture warranted re-exploration of the pericardial sac by Churchill, again with negative findings.

CASE REPORT

N. B., a 23-year-old man, gave a history of abdominal distention for three months. Six liters of fluid were removed before admission. The abdomen was tense with fluid. The blood pressure was 126/96, the venous pressure 19 cm. After the customary preparation, operation was performed, July 19, 1940. The approach was a left transpleural intercostal one. The external pericardium was apparently not thickened although somewhat opaque. Cardiac pulsations were normal. The pericardium when incised was found to be very slightly thickened. The lesion was an adhesive fibrosing one of the visceral and not of the parietal pericardium. After the visceral membrane was generously removed the cardiac action was free but the heart did not bulge through the gap in the parietal pericardium.

The postoperative course was uneventful. There has never been a return of ascites. It is now almost four years since operation. The patient has remained symptom-free in a physically active occupation.

5. *Exploratory Pericardiotomy and Secondary Pericardiostomy for Suppurative Pericarditis.*—The suture of the margins of the opened pericardium to the thoracic incision facilitates greatly the drainage of an infected sac but does not always solve the problem. Thus, undrained collections may be found at autopsy. With this in mind the following patient was subjected to exploratory pericardiotomy after drainage for suppurative pericarditis had already been instituted.

CASE REPORT

B. S., a boy 5 years old, had been operated upon at another institution for suppurative pericarditis as a metastatic focus derived from the humerus. At the operation several weeks before admission, when the patient's condition was desperate, a large quantity of pus under tension was evacuated. The general condition rapidly improved, the patient became afebrile, but rather profuse discharge of pus from the wound continued. At operation at Mount Sinai Hospital the pericardium was widely exposed extrapleurally and carefully incised without preliminary aspiration. Purulent exudate was encountered. Fur-

ther dissection revealed not only additional purulent exudate but also surprisingly large collections of pus both in front and behind the heart. Painstaking irrigations were required over a period of weeks before the pericardial sac was clean and could be permitted to heal. It has remained healed.

6. *Pericardiotomy for Acute Pericarditis of Low-Grade Virulence.*—The following is the only instance in my experience in which an exploration disclosed an inflammatory lesion of obviously low-grade virulence.

CASE REPORT

C. K., a 68-year-old woman, was operated upon for diaphragmatic hernia at another institution, in October, 1942. A transthoracic operation was performed. It was followed by fever. Several thoracenteses were performed. Fever continued unabated. On admission in January, 1943, it was thought (roentgenograms difficult to interpret) that an intrapleural suppurative focus existed in the region of the pericardium. At operation, January19, a suppurative focus was not found. The surface of the pericardium appeared congested and possibly thickened. Aspiration revealed turbid yellow fluid (culture was reported later as sterile). The pericardial sac was laid open freely and found to be occupied by fibrinous exudate and small pools of yellowish fluid. The margins of the pericardium were sutured to the soft parts of the thoracic incision. The skin was strapped. (Report on specimen from pericardium: acute inflammation. No organisms found in sections.) Postoperative dressings consisted of unstrapping of skin wound, evacuation of clear fluid, and restrapping of wounds upon several occasions until healing occurred.

After a fever-free interval fever returned and another exploration for a suspected intrathoracic abscess was performed on February 19. None was encountered. The pericardial sac was opened and found to be free from infection. The patient was discharged in a fever-free interval.

7. *Pericardiotomy for Better Exposure of the Patent Ductus in the Presence of Subacute Endarteritis.*—The brilliant results achieved by Touroff and subsequently by others with the ligation of the ductus in the presence of subacute endarteritis were offset in a measure by occasional disastrous hemorrhage at the time of operation. The source of hemorrhage was the posterior surface of the ductus and the cause (in addition to the possible or probable friability of the ductus when the seat of endarteritis) was the difficulty of dissection in this region. It was apparent that although the ductus is outside, but immediately adjacent to, the pericardium the exposure of the structure would be facilitated by incising the pericardium and retracting the dilated pulmonary artery. This was first tried in a patient without endarteritis and, found to be useful for the purpose, was applied in two with en-

darteritis. One case is described. In view of current reports it should be stated that a course of penicillin must be tried before subjecting patients with patent ductus to ligation during the period of subacute bacterial endarteritis.

CASE REPORT

M. N., a woman 30 years old, was admitted Sept. 27, 1943, with a three months' history of fatigue and fever. The diagnosis of subacute bacterial endarteritis was established elsewhere and full dosage of sulfadiazine was administered. There had been one episode of pulmonary infarction. On admission there were noted the characteristic machinery murmur and phonocardiogram. The blood culture was positive for *Streptococcus viridans*. At operation the mediastinal pleura was incised in the customary manner, and the recurrent nerve visualized beneath the aorta. The ductus was found to occupy a lower position than usual and was short and extremely wide (1½ cm. long, 2 cm. wide). The dissection for its release was begun on the superior and inferior surfaces but it soon became evident that dissection under vision would not be possible on its deep surface. In the hope of obviating more or less blind and dangerous dissection in this region mobilization of the enormously dilated pulmonary artery was decided upon. This was made possible by incising the pericardium radially and freely over the region of the left auricular appendage. The incision was prolonged to the beginning of the ductus. A gauze pad was placed over the pulmonary artery which was drawn downward and medially. The deep surface of the ductus was visualized thereby and its dissection was readily accomplished. Two silk ligatures closed the ductus with disappearance of the thrill. The pericardium was not sutured. Blood pressure before ligation was 86/64, after ligation 100/70.

There was an accumulation of bloody pleural fluid after operation of which 350 c.c. were aspirated. There were also two chills in the first postoperative days. Otherwise, convalescence was satisfactory and all blood cultures were negative, including the one immediately after ligation of the ductus. It is now seven months since operation. The patient is symptom-free and does the active work of a housewife.

DISCUSSION

DR. STUART W. HARRINGTON, Rochester, Minn.—I have not used pericardiotomy in the treatment of ductus arteriosus, but for the past two years I have used a posterolateral approach for exposure in the surgical treatment of ductus arteriosus both in the infected and noninfected ones.

I believe that this approach has very definite advantages over an anterior approach. The exposure is more adequate. It is particularly advantageous if the pleura is adherent since the lung can be separated from the apex permitting exposure of the ductus. It is also very adequate in the infected patent ductus where there are many adhesions and enlarged lymph nodes around the ductus. It has the ad-

vantage of a bilateral approach to the ductus. If hemorrhage should inadvertently occur during the separation of the ductus, the surgeon is in a position to control it by compression of the fingers until the ductus can be ligated, which I have found necessary to do in one of my cases.

The posterolateral incision is made around the angle of the scapula with resection of the posterior two-thirds of the fourth rib and in some instances an additional exposure can be obtained by resecting a small segment from the angle of the adjacent ribs. The pleural cavity is entered through a posterior periostomy of the fourth rib.

DR. JOHN C. JONES, Los Angeles, Calif.—I have not opened the pericardium of any of the patients in whom I have ligated the patent ductus arteriosus. Gross of Boston, who has had the most experience with the ligation of the ductus arteriosus, makes a very definite point, and I think a very good one. I feel certain he was referring to the ligation of the ductus arteriosus in patients with infection. He believes there is a definite disadvantage in opening the pericardium because there is a trickle of pericardial fluid through that opening which obscures the field of the dissection, and I have not seen any noninfected ductus arteriosus which required the opening of the pericardium for ligation.

I should like to make one point, however, that the more ductus one ties, the greater variety of dissections one encounters. I think in some cases the ductus appears short because of the reflection of the pericardium up over the ductus, extending to the aorta. Some that are not infected, where there are no enlarged lymph glands, appear as though there had been infection, even in young children. Going anteriorly and antromesially toward the right main stem bronchus, the dissection is difficult. If one carefully dissects down, removing and cutting these fibrous reflections from the pericardium up toward the aorta, one is surprised how much longer the ductus arteriosus actually is than it appeared originally when the dissection was started.

I quite agree with Dr. Gross that there is a definite disadvantage to having the pericardium opened in the region of the ductus because of the trickle of fluid. There is another point I would like to make as far as opening the pericardium is concerned in malignant tumors.

About one and one-half years ago I operated upon a boy about 9 years old who had a recurrence of an upper abdominal wall tumor which had been reported as a fibrosarcoma and which obviously not only involved the abdominal wall, but also the costal cartilages. After removing the large abdominal wall tumor and dissecting upward to resect the costal arch on the left, it was seen that the tumor involved the left diaphragm anteriorly and the left pleural cavity, so that was removed. Then the dissection was made mesially and posteriorly, and it was found that the pericardium was involved. Therefore, I had to remove the lower two-thirds of the anterior pericardium.

Then, extending over to the right, it was observed that the anterior right leaf of the diaphragm and the right pleura anteriorly were infiltrated with new growth, and had to be removed. The dissection was carried on downward so that I had all four cavities opened widely at one time. It was a beautiful demonstration of controlled anesthesia. It was necessary to use the liver in order to close the wound, but the liver makes an admirable closure of the abdominal wound, provided there has been enough fibrosis from the previous operation in order to stitch it to the remains of the abdominal wall anteriorly. This patient had an uneventful convalescence and is well thus far.

DR. CAMERON HAIGHT, Ann Arbor, Mich.—The indication for partial resection of the pericardium in conjunction with the removal of tumors of the lung

is rare. The first instance that I am aware of is one mentioned by Clarence Crafoord of Stockholm in his monograph *On the Technique of Pneumonectomy in Man*, 1938.

I would like to call your attention to an interesting observation in a patient for whom a pneumonectomy with the resection of a large area of the pericardium was performed three years ago. The lesion, which proved to be a squamous-cell carcinoma, was situated in the lingular portion of the left upper lobe. The diaphragm was moving two weeks before operation, but on the day before operation, there was complete diaphragmatic paralysis. As the involvement of the phrenic nerve was recent, operation was done in spite of the fact that local extension of the tumor to the pericardium and phrenic nerve was anticipated. It was hoped that the extension was sufficiently recent, so that it would be possible to remove the local metastases in conjunction with the lung. An anterior approach was used, and the tumor in the upper lobe was found to be adherent to and invading the pericardium over an area about 4 by 5 cm. in diameter. The phrenic nerve was involved in the growth.

The pericardium was opened and an encircling incision about 1 cm. wide was made of the neoplastic infiltration in the wall of the pericardium. The involved area of pericardium was left attached to the lung and was removed in conjunction with the lung. After fixation in 10 per cent formalin, the resected area of pericardium measured 6.4 by 5.4 cm.

During the removal of the lung, the exposure of the pulmonary pedicle was maintained by the assistant's hand which incidentally maintained slight pressure against the heart, thus keeping it in place. On releasing this pressure after removal of the lung, the heart immediately herniated through the large opening in the pericardium, and the apex of the heart almost touched the thoracic wall laterally. To describe the phenomenon more vividly, the heart actually flopped out of the pericardial cavity. This resulted in a sudden kinking and torsion of the vessels at the base of the heart. The blood pressure became inaudible and the pulse imperceptible. By pressing upon the heart it could be returned into the pericardial cavity and by tilting the patient to the contralateral side at an angle of about 20 degrees, the heart remained within the pericardium. As soon as the heart was returned to its normal position, the blood pressure and pulse rate returned to the levels that were present before the incident occurred. The opening in the pericardium was much too large to be closed by suture. Although the use of a free fascial graft was considered, this possibility was abandoned because of the additional time that would be required and the unforeseen difficulties that might be encountered. More importantly, it was believed that the herniation of the heart could be prevented by keeping the patient turned on or toward the countralateral side.

After closure of the wound, a loud clicking noise, similar to a knock, could be heard and felt with each heartbeat. During the first day after the operation the intensity of the sound was so great that it could be heard when one was standing in the doorway of the patient's room, the patient being at the opposite end of the room at a distance of about twelve feet. The intensity of the sound gradually subsided during the next several days and then completely disappeared coincident with organization of the pleural fluid within the empty pleural cavity.

It was necessary to keep the patient inclined toward the contralateral side after operation. At one time during the first few hours after operation, the patient was inadvertently allowed to be flat on his back, and he immediately developed severe shock, which was promptly corrected by again turning him toward the right side.

As I do not recall that this phenomenon of herniation of the heart, in a patient for whom a large pericardial opening was not closed, has been described previously, I felt that it would be of interest to mention it as well as the use of posture in

controlling this complication. Although three years have elapsed since operation, the patient is well and he has no evidence of cardiac embarrassment or recurrence of the tumor.

DR. EVARTS A. GRAHAM, St. Louis, Mo.—A number of years ago Sauerbruch described the procedure of leaving the pericardium open for drainage into the pleural cavity as in cases of intractable pericardial effusion. I had occasion about four years ago to carry out that procedure in a woman who had a recurrence of a carcinoma of the breast in the pericardium with massive bloody effusion in the pericardium which required frequent tapping. By the simple procedure of removing some of the pericardium and letting the rest of it drain into the left pleural cavity the woman was perfectly comfortable for a period of about two years before she died, finally, of further recurrences.

This was an exceedingly simple procedure and one which gave great comfort to the patient.

DR. JEROME R. HEAD, Chicago, Ill.—I had one rather peculiar accident incident to opening and closing the pericardium. I believe that it might be worth while to report it. The left auricular appendage extends down beside the arterial cone. At each heartbeat this thrusts forward.

In taking out a pericardial cyst, I tore the pericardium, and at the end of the operation, which was a perfectly simple one, I started to close it with a running stitch. Through the early part of the closure I could see the needle but was unable to watch it during the last stitch. This was followed by a tremendous gush of blood through the remaining opening and into the pericardium. I opened the sac widely and found that my needle had torn a piece out of the auricle which had come down and hooked my needle. It emitted a stream of blood about the size of a lead pencil.

I put my finger on it and inserted a stitch in the end of the flap for traction. The stitch immediately pulled out. Fresh bleeding developed at the site of the stitch. I then tried to grasp it on the side with a hemostat and ended by having more bleeding. My assistant finally suggested that I take an ovum forceps and grasp the whole appendage, which I did, and then ligated back of the forceps. This controlled the bleeding. The patient made an uneventful recovery except for two or three weeks when he had almost daily attacks of paroxysmal tachycardia. I believe that this is worth reporting as being the only way in which one can control bleeding from this part of the auricle.

DR. FRANK S. DOLLEY, Los Angeles, Calif.—There is a point that has not been emphasized despite the splendid discussions of this paper. Following pericardiotomy there may be no apparent counterindication to closure of the pericardium. It should be borne in mind, however, if there is any trauma at all, serum in considerable amount may collect in the pericardial sac. If the pericardium is completely closed, tamponade may occur and, under the care of an intern unused to this complication, lead to the patient's death.

Even if the pericardium is left open, unless there is some provision for drainage other than leaving it open, an accumulation of serum in the immediate vicinity of the opening of the pericardium may occur leading to a backup into the pericardial sac and to serious or fatal tamponade. In other words, some type of drainage (rubber tissue) to the outside or into the pleural cavity in cases where the serum is likely to form in considerable quantity is a necessary safeguard.

A tamponade developing during the night might lead to death without the nurse being aware of change for the worse.

THE MANAGEMENT OF STRICTURE OF THE ESOPHAGUS

With Special Reference to Complete Stricture of the Mid-esophagus With a Detailed Report of Two Cases

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THE common conditions of the esophageal wall with obstruction are cancer of the esophagus, esophageal diverticulum, cardiospasm, web (both with and without the Plummer-Vinson syndrome), cicatricial stricture secondary to caustic burns, cicatricial stricture secondary to peptic ulcer or esophagitis often associated with peptic ulcer below the esophagus, cicatricial stricture secondary to or associated with surgical procedures, cicatricial stricture secondary to tuberculous glands of the mediastinum, and congenital developmental anomalies, named in the order of greatest frequency.

The method of treating esophageal strictures is dilatation of the narrowed area. A satisfactory result is obtained when the dilatation is sufficient to allow the passage of a regular diet without difficulty. Until this is accomplished, the diet may be altered to admit its passage through the narrowed esophagus.

The amount of dilatation or distention that may be obtained in tissues by the application of pressure is, to say the least, amazing. In the esophagus we see diverticula that have become as large as a grapefruit, and the esophagus may attain a circumference of ten inches as the result of continued pressure from its fluid content and by the added pressure exerted by the muscles of deglutition.

The passage of any instrument through the esophagus is fraught with danger for trauma to the esophageal wall may result in mediastinitis, while perforation or rupture produces mediastinitis except in rare instances. The mediastinitis spreads rapidly and terminates fatally in almost all instances unless radical measures are taken to drain the mediastinal infection and limit its spread. In such cases the judicious use of the sulfonamides and penicillin must not be overlooked.

The frequency and the amount of dilatation vary with the individual case, and this is governed by the experience and judgment of the attending physician. Once dilatations are begun, the tragedy of breaking of the esophageal wall reflects upon the judgment of the operator.

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Read at the Twenty-fifth Annual Meeting of the American Association for Thoracic Surgery, Chicago, Ill., May 5 and 6, 1944.

CARCINOMA

Since dilatation can in no way be a cure for carcinoma, it may be used in giving palliative relief, improving nutrition and delaying gastrostomy or death. Dilatations have been carried out both with the esophagoscope and with the previously swallowed thread as a guide, obtaining pronounced relief over a period of time.

PHARYNGO-ESOPHAGEAL DIVERTICULUM

The only logical treatment of these diverticula is surgical removal. Symptoms of a small pharyngo-esophageal diverticulum may be relieved to some extent by dilatation of the upper end of the esophagus.

We believe that dilatation of the upper end of the esophagus following operation decreases the tendency toward recurrence of esophageal diverticula, and in a few cases dilatations of this area have been necessary due to narrowing following the operative procedure.

CARDIOSPASM

A review of the etiologic theories of esophageal achalasia is unnecessary. There is narrowing or stenosis of the lower end of the esophagus which produces symptoms that may be relieved by dilating the narrowed area. In 112 cases of cardiospasm requiring treatment, we encountered 4 with advanced torsion, in which dilatation failed to give satisfactory relief, and operative treatment was advised. Yet 3 of these 4 patients have managed to exist with considerable discomfort, and 1 died of pneumonia several weeks after a gastrostomy had been performed to maintain nutrition. The remainder were dilated with control of most of their symptoms.

For years it was our practice to visualize the lower end of the esophagus through the esophagoscope, balloon the esophagus and pass dilators, and usually the esophagoscope, into the stomach. At this time a Tucker-Plummer bag was passed through the esophagoscope, the esophagoscope was withdrawn, and the Tucker bag was dilated to eight pounds pressure or until severe pain was produced. Following the esophagoscopic procedure, a modified Plummer bag, measuring one inch in diameter, was placed in the narrowed area under fluoroscopic guidance. It was inflated until pain was produced or until eight pounds of pressure was reached. The dilatations were carried out at intervals of one to three weeks until considerable improvement in the symptoms had occurred. If the symptoms were not relieved, the pressure was increased gradually over a period of months until twelve or even fifteen pounds of pressure was used. Following the suggestion of others, we began applying the higher pressure early in the course of treatment, and found that the results were much better in that the time required and the number of treatments were greatly decreased.

This year suppurative mediastinitis occurred in 2 cases following such dilatation. These are included in the 4 cases of mediastinitis to be mentioned later in this communication. Although both patients recovered after prompt surgical drainage, we were convinced that such rapid dilatation, while effective, was too dangerous for further use. Henceforth, we shall follow our former policy of gradual dilatation, accepting the inconveniences of increased frequency of dilatation and the time required rather than risk esophageal rupture.

Leakage occurred once under general anesthesia, which was given at the insistence of an extremely nervous and temperamental patient. In addition, too great pressure was used. This complication must be classified as secondary to an error in judgment, as the pain reflex should be preserved as a safeguard during esophageal dilatation for cardiospasm.

WEB

Webs with and without the presence of the Plummer-Vinson syndrome have been encountered in 42 cases. The treatment of web is usually dilatation; however, a few have been removed with a punch forceps. In many cases the initial dilatation relieves the patient indefinitely, although a few require repeated treatment. One patient returned six years after dilatation with further difficulty in swallowing. She was found to have a carcinoma in the upper esophagus.

CHEMICAL BURN

Sixteen patients with stricture of the esophagus resulting from chemical burn have been treated with relief of symptoms, 2 of which are reported here in detail. Four other patients have been seen, but went elsewhere for treatment or rely on a gastrostomy for feeding.

None of these patients was seen early or during the acute stage of the burn. They came to us weeks, months, or even years later, when discouraged by the lack of progress, or in difficulty either from their own neglect of treatment or inadequate treatment.

The only really troublesome difficulty encountered was re-establishment of an opening in a completely stenotic esophagus. If the patient was able to swallow liquids, no trouble was encountered. Once a guiding thread was passed through the strictured area from a gastrostomy opening through the mouth, persistent gradual dilatation accomplished a satisfactory result. The Tucker retrograde rubber bougie was used in the early phase of treatment of the most difficult cases.

PEPTIC ULCER AND ESOPHAGITIS

Strictures associated with peptic ulcer of the lower end of the esophagus or a severe esophagitis associated with peptic ulcer below the esophagus have required repeated dilatations in 15 cases. One patient was completely obstructed and had been maintained on parenteral feedings for three weeks before coming for treatment. A gastrostomy

was done and retrograde dilatation carried out. In the remaining cases, after appropriate esophagoscopy, biopsy, and diagnostic studies, the swallowed thread was used as a guide for the repeated dilatations. All of these patients were greatly improved for long periods, some being entirely symptom-free. Two had a return of symptoms after being well for five and seven years, respectively. It is interesting to note that a large percentage of these patients with peptic ulcer of the lower end of the esophagus had a short esophagus and a small diaphragmatic hernia.

SURGICAL PROCEDURES

As a sequel to the treatment of carcinoma of the stomach by total gastrectomy and esophagojejunostomy in 68 patients, 6 patients developed a partial stricture at the anastomosis within a few weeks or months after the operation. All responded to repeated dilatations and here again a swallowed thread was useful as a guide. We have seen 2 patients in whom a portion of the cervical esophagus, 5 cm. and 1.5 cm., respectively, was removed accidentally during thyroid surgery. Complete obstruction had existed for six weeks in 1 case and for one year in the other.

Fortunately, neither patient developed a spreading mediastinitis, which may well be explained by the open drainage of the thyroid wound. Treatment was carried out by an open operation of the area of the cervical esophagus with peroral and retrograde esophagoscopy. In the patient with the smaller defect, a flap of mucous membrane was turned down from the upper segment and sutured in continuity with the mucous membrane of the lower segment. A thread was placed for retrograde dilatation.

In the patient with the larger defect, a thread was placed without any attempt to bridge the defect with mucosa. Retrograde dilatations have been carried out and, surprisingly enough, this patient is able to eat a normal diet; but dilatations to a No. 41 French bougie are still being carried out at three-week intervals over a previously swallowed thread.

In a case worthy of mention an early carcinoma was diagnosed in the upper end of the esophagus. An open operation through the neck was carried out, removing the entire carcinoma, and leaving a strip of mucous membrane approximately 6 mm. by 5 cm. connecting the hypopharynx and the esophagus. Repeated dilatations were carried out following this procedure, and at this writing, eleven years later, the patient is asymptomatic, and a 7 mm. esophagoscope can be passed with ease through the upper esophagus.

TUBERCULOSIS OF THE MEDIASTINAL GLANDS

Tuberculosis of the mediastinal glands is not uncommon and often produces a traction diverticulum. In a relatively few cases, however,

a scar tissue stricture is produced which requires repeated dilatations. Five such patients have been treated, 1 of whom required dilatations at intervals over a period of seven years before she became asymptomatic.

CONGENITAL NARROWING OF THE ESOPHAGUS

In 2 cases a congenitally narrow esophagus was present. One patient was a girl 9 years of age, and the other was a man of 49 years. Both had lived their entire lives on fluids and strained foods, never having taken a normal meal. Both responded readily to repeated dilatations.

REPORT OF CASES

CASE 1.—Nov. 24, 1942, a 60-year-old man accidentally swallowed a quantity of wood-staining compound. He recovered promptly from the severe systemic shock, but during the next two months he developed a complete esophageal stricture. He lost twenty pounds in weight. For several days prior to admission all intake by mouth was regurgitated and he was sustained by intravenous fluids.

He entered the hospital Feb. 23, 1943, three months later. The general physical examination was not remarkable, except for dental caries and gingivitis. Gastrostomy was advised but refused. February 25, esophagoscopy demonstrated complete obstruction at the middle third of the esophagus with some ulceration of the wall above the stricture. The lumen was represented by a dimple of granulation tissue, through which a No. 10 Jackson bougie was passed without difficulty. Larger dilators, up to No. 16, were then passed. Following dilatation the esophagus was easily inflated with air, and a swallow of warm water seemed to go through without apparent discomfort to the patient. A few minutes later a sharp lancinating pain in the upper abdomen occurred. Because of the possibility of perforation and emphysema of the mediastinum, roentgenograms were taken which showed no sign of mediastinal disease.

Steady boring pain under the right costal margin and xiphoid process persisted, but the temperature and pulse rate, after initial elevation within the first eight hours, subsided to normal in eighteen hours, and serial white blood counts at two, six, and eighteen hours were 6,900, 19,900, and 17,000, respectively. At thirty hours the temperature was 101° F., pulse rate 120, and the leucocytes numbered 31,000. Roentgenologic examination with a portable machine showed an elevated right diaphragm. The pain had increased and was made worse by deep inspiration. The diagnosis of acute suppurative mediastinitis was obvious.

February 26, thirty-four hours after esophagoscopy, a right posterior mediastinotomy through the bed of the eighth rib yielded 600 c.c. of thin foul-smelling pus containing anaerobic hemolytic streptococci.

The patient recovered after a prolonged convalescence. A gastrostomy was established on March 5, eight days after the mediastinotomy.

The initial retrograde bougienage with passage of a thread was performed April 6, forty-one days after the esophagoscopy, and he was discharged April 9. Dilatations were continued over the thread at weekly intervals for several months until the esophagus had a diameter of a No. 45 French (1.5 cm.) bougie, and he was taking a normal diet without restriction or discomfort. The gastrostomy tube was removed, and he has continued well, receiving interval dilatations to maintain a satisfactory lumen through the stricture.

CASE 2.—A 29-year-old woman was admitted to the clinic Sept. 30, 1943, with cicatricial obliteration of the mid-thoracic esophagus of seven years' duration. The stricture was caused by the swallowing of a corrosive solution, and since that episode she had been unable to take even liquid nourishment by mouth. A gastrostomy stoma established shortly after the misadventure had furnished a means of providing adequate nutrition.

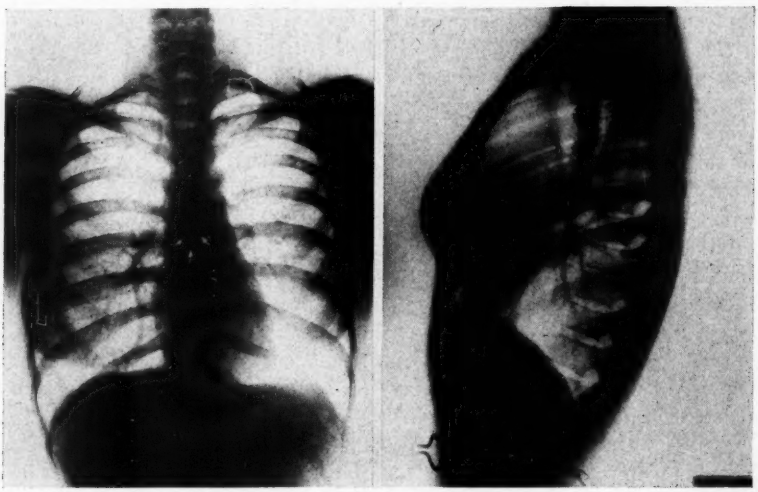

Fig. 1.

The findings of the general physical and laboratory examinations were within normal limits. Complete occlusion of the mid-thoracic esophagus 3 cm. below the aortic arch was demonstrated by fluoroscopy, roentgenograms with barium in the upper esophagus, and air insufflated into the lower esophagus through the gastrostomy opening (Fig. 1). Peroral esophagoscopy showed partial cicatricial contracture at the cricopharyngeus muscle, and the mid-esophagus ended abruptly in a cord of scar tissue without a lumen. By retrograde esophagoscopy, fibrous narrowing below the mid-esophageal stenosis was seen. These studies confirmed the diagnosis of fibrous obliterative stricture of the mid-esophagus, 2 cm. in length.

October 6, the stricture in the esophagus was widely exposed through a right transpleural and mediastinotomy incision. An esophagoscope was advanced to the stricture from above and another esophagoscope as near to its lower end as possible through the narrowed esophagus. The endoscopist introduced from below an aspirator used as a probe and exerted gentle pressure upon it, while the surgeon held the fibrous occluded esophagus between his fingers and guided the probe through its central portion. The task of traversing the 2 cm. stricture was most difficult and consumed more than one hour, but gradually a new lumen

Fig. 2.

was made without perforation. After the aspirator was through the stricture, it was held steady between the surgeon's fingers. The endoscopist used a stream of saline to wash a silk thread down the upper esophagoscope. The thread was drawn into the aspirator by suction and the aspirator was pulled back within the lower esophagoscope.

While the endoscopist and surgeon were concentrating upon the removal of the upper esophagoscope with retention of the thread through the stricture, the lower esophagoscope and aspirator were held by an attendant. Inadvertently the lower esophagoscope was allowed to slip

backward into the stomach, and the end of the aspirator penetrated the esophagus 2 cm. above the cardiac orifice but several centimeters distal to the lower margin of the stricture. The injury to the esophageal wall was only the diameter of the aspirator, and it was immediately closed. This injury to the normal wall of the esophagus, after the successful execution of the preoperative plan for passage of the stricture and because of momentary diversion of personal surgical and endoscopic attention from a minor technical detail, was most exasperating.

Sulfanilamide was placed about the esophagus and a drain was carried from the mediastinum out through the chest wall incision. This patient also recovered.

November 10, thirty-five days after the operation, retrograde dilatation with Tucker bougies was begun. Gradually the lumen of the esophagus was increased until the patient could take a normal peroral diet. January 20, 1944, fluoroscopy with barium and roentgenograms showed the esophagus to have a lumen with mobile walls, and vigorous peristaltic waves passed along its entire course including the area of stricture (Fig. 2). The patient returned shortly afterward to her home in Trinidad, taking with her a set of Tucker retrograde bougies, with which dilatations have been continued by her local physician. When last seen at the clinic the stricture had a diameter of 9 mm. By report from the patient, progress has continued satisfactorily. The gastrostomy eventually will be closed.

DISCUSSION

An ingested corrosive solution is likely to cause stricture formation at one or more of four narrow points along the course of the esophagus. These are at the upper sphincter or cricopharyngeus muscle, at the crossing of the esophagus by the aortic arch, at the passage of the esophagus under the left primary bronchus, and at the lower sphincter or cardia. Observation of stricture cases indicates that the transient physiologic delay of food masses occurring at these locations makes possible increased local tissue injury when the swallowed material is a strong chemical irritant.

In Case 1 the stricture was at the aortic arch. In Case 2 it was near the left primary bronchus, although there was partial stricture formation both at the cricopharyngeus muscle and at the aortic arch.

Beyond the appropriate general treatment, the most important point for the physician to keep in mind is the prevention of complete esophageal obstruction in the early management of chemical injury of the esophagus. This is possible by having the patient swallow a thread promptly when there is any difficulty in taking liquids. This maintains a potential lumen even after extensive corrosive injury and also furnishes the essential guide for later dilatation. Passage of the

thread through the intestinal tract allows adequate anchorage, and the portion within the esophagus should be kept strong and fresh by providing a constant supply from a bobbin. Should a gastrostomy be needed for feeding purposes, the thread may be brought out through that opening. With such an indwelling thread as a guide, gentle dilatation may be started within a few weeks of injury. We have not had occasion to employ the method wherein flexible mercury-filled bougies are passed from the first day following injury. In both cases here described, the esophageal lumen had been lost completely at the site of stricture for want of an inlying thread.

Dilatation is most safely attempted over a guiding thread. Tortuous or extensive strictures usually can be more safely dilated by retrograde bougienage with Tucker bougies through a gastrostomy opening than with solid metal dilators from above even with a guiding thread. This in itself is adequate reason for gastrostomy even if it is not essential for temporary feeding purposes.

As the first patient could not pass a thread through the stricture by swallowing and refused to allow gastrostomy, it would seem better judgment by hindsight to have declined the responsibility for treating him than to be forced by events to accept responsibility for a perforation that might not have occurred under the regimen of treatment considered preferable. The perforation produced by peroral dilatation, we believe, might have been prevented had gastrostomy been performed and retrograde bougies passed.

The risk of fatality in the treatment of strictures such as occurred in Case 2 has been so high that many have remained untreated. We felt that it presented too hazardous a situation to attempt endoscopic procedures alone, because the stricture itself was completely fibrous and of considerable length, and because the portion of the esophagus below the obliterated area could not be well visualized because of narrowing. On the other hand, we were quite certain that gradual dilatation would in time permit satisfactory resumption of function if the strictured area could be canalized without causing a fatal mediastinal infection. This opinion is based upon our experience with the previously mentioned cases of esophageal stricture from various causes in which treatment by repeated dilatations was most satisfactory.

In the absence of an indwelling thread or endoscopic means of safely passing one, the possible alternatives were debated. The most obvious solution was to refrain from any treatment and let an otherwise healthy woman of 29 years attain life expectancy on gastrostomy feeding. The patient was more than willing to take risks to regain the privilege of eating by mouth. An external esophagoplasty was considered and discarded after analogy with this procedure for carcinoma of the esophagus in which several operative stages produce an arrangement devoid of cosmetic appeal and rarely resulting in perfect function al-

though admittedly preferable to persistent cervical and gastric fistula. The possibility of resection of the stricture and end-to-end esophageal anastomosis was not forgotten, but to our knowledge this procedure has never been accomplished successfully in an adult.

We concluded that the stricture could be opened and a thread passed by coordinating the services of both a thoracic surgeon and an endoscopist. Open mediastinotomy and exposure of the stricture with the thoracic surgeon guiding the end of a probe inserted by the endoscopist seemed to offer a method of penetrating the stricture, preventing false passage, and avoiding the serious complication of diffuse mediastinitis should perforation occur. Our belief was substantiated in that the procedure succeeded. The embarrassing incident of having the normal esophageal wall penetrated did not prove serious because the opening was immediately closed and prophylactic drainage provided a safeguard against spreading mediastinitis.

Although mediastinitis is not the subject of this communication, it is such a constant hazard to the patient with an abnormal esophagus that management of stricture cannot be discussed properly without mentioning it. The points we would like to emphasize after treating 4 patients, all of whom recovered, are: Substernal, upper abdominal, or shoulder pain is the most constant sign. If after a few hours the pain is increased by deep inspiration, the sign is pathognomonic. If a patient with normal temperature, pulse rate, and leucocyte count has an esophageal procedure and within a few hours develops pain, fever, elevated pulse rate, and leucocytosis, and becomes clinically sick without obvious reason, the only likely cause is mediastinitis.

Roentgenologic assistance is desirable but to be worth while must be obtained under conditions that allow adequate examination. Roentgenograms made with a portable machine are of little value except as confirmation of mediastinal infection that has advanced so as to be clinically obvious and probably approaching a fatal termination. If a patient with suspected mediastinitis is too sick to go to the x-ray room, he should be operated upon, since portable films are unlikely to yield additional data. On the other hand, if he has signs serious enough to merit consideration of mediastinitis as a diagnosis, early and adequate roentgenologic examination may give vital information. This should include fluoroscopy without and then with barium in the esophagus. A diaphragm of limited excursion or elevated position is most significant. After fluoroscopy, posteroanterior and lateral views should be taken. The appearance of a droplet of barium outside the esophagus is, of course, conclusive, but clouding of the cardiophrenic angle alongside the inferior pulmonary ligament and the appearance of a small quantity of fluid at the costophrenic angle on the ipsilateral side in combination are almost equally diagnostic.

One should beware of improvement in the clinical chart and leucocyte count between eighteen and twenty-four hours after a suspected

perforation in the presence of continued pain for reliance upon these changes gives false hope and decreased security. If a mediastinotomy is to be performed, a simple gastrostomy with insertion of a tube should always be done immediately preceding it.

SUMMARY

Observations and experiences in the management of stricture of the esophagus from various causes are reported, with particular emphasis upon the problems encountered and the treatment used in cases of complete stenosis secondary to chemical burns.

(*See discussion on page* 423.)

SURGICAL TREATMENT AND CLINICAL MANIFESTATIONS OF BENIGN TUMORS OF THE ESOPHAGUS WITH REPORT OF SEVEN CASES

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THE occurrence of benign tumors of the esophagus is relatively infrequent. Their subjective symptoms and clinical manifestations are often meager, which not only delays their clinical recognition but also makes it difficult. These growths are potentially malignant and their treatment is of special interest to the surgeon because extensive operative procedures may be required for their removal.

These benign tumors may be divided into two main groups: the mucosal and the extramucosal tumors. The mucosal tumors are often pedunculated and arise from the submucosa. They usually are fibrolipomas or fibromyxomas and are covered by normal epithelium of the esophagus. The extramucosal or intramural tumors arise from the muscle of the wall of the esophagus; they do not involve the mucosa and usually are leiomyomas.

The growth of benign tumors of the esophagus is usually slow and they may attain considerable size without giving rise to subjective symptoms. This is particularly true of the intramural tumors, which rarely produce obstruction of the esophagus unless they attain great size. The common symptoms associated with these growths are dysphagia, substernal pain, regurgitation of food, cough, and dyspnea. The pedunculated tumors are commonly associated with obstructive symptoms and the diagnosis of these growths is often definitely established by regurgitation of the tumor into the mouth, which may be the first subjective symptom. Regurgitation of these growths into the nasopharynx can imperil life owing to blocking of the trachea, which may result in strangulation,

The roentgenographic and roentgenoscopic examination of the esophagus is of great value in determining the presence of these growths. Esophagoscopic examination is of utmost importance in establishing a definite diagnosis, although at times it may be difficult to determine the site of origin as well as the type of growth because of the difficulty in obtaining a specimen for biopsy through the normal esophageal mucosa. The site of origin of the pedunculated tumors usually can be determined definitely.

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Read at the Twenty-fifth Annual Meeting of the American Association for Thoracic Surgery, Chicago, Ill., May 5 and 6, 1944.

The indications for surgical treatment of benign tumors are not as urgent or as imperative as for malignant lesions of the esophagus. They depend somewhat on the patient's general condition, the amount of difficulty the tumor is causing, and the site of the tumor. Inasmuch as these growths may undergo malignant change, surgical treatment should be considered in all cases.

The surgical treatment of these tumors depends on whether the growth is submucous or pedunculated or on whether it arises from the outer portion of the muscular coat of the esophagus. The pedunculated tumors may be more accessible and amenable to surgical treatment than the intramural tumors. If the pedunculated tumor is small and its origin is high at the introitus, it may be removed through the mouth with a snare and cautery. Larger tumors of this type require cervical esophagotomy. These tumors may attain such huge size as to require transthoracic esophagotomy. This approach also may be necessary if the pedicle of the tumor is situated low in the esophagus.

The indications for surgical treatment of intramural tumors are not as a rule as urgent as those for pedunculated tumors because intramural tumors do not usually cause obstructive symptoms. The surgical treatment of these tumors often requires a much more extensive operative procedure than is necessary in cases of pedunculated tumors. If the intramural tumors involve only a segment of the wall of the esophagus they may be removed by local excision of the tumor from the wall of the esophagus, which is then reconstructed. If the growth involves the entire esophageal wall, its removal will require resection of the esophagus, which entails a greater operative risk.

REPORT OF CASES

We wish to report seven cases of benign tumors of the esophagus. In five of these esophagotomy was performed, in one case resection of the esophagus was employed, and in one case the tumor was removed orally with a snare and cautery. In one of the cases in which the tumor was removed by esophagotomy, the operation was performed by Dr. E. S. Judd, in 1921.

CASE 1.—A man, aged 42 years, came to the Mayo Clinic Oct. 21, 1943. His chief complaint was gradually increasing regurgitation of food, of eight years' duration. He had had two severe attacks of hiccups twenty and fourteen years before, respectively. Each of these attacks had lasted for about three days. They finally had been relieved by intravenous administration of a narcotic and strapping of the abdomen. He first had noticed difficulty in swallowing food eight years before he came to the clinic. This first had been noticed after he had eaten a heavy meal. During the next two to three years he had moderate dysphagia, especially when he had been eating bread. After he had eaten he promptly had regurgitated food in an undigested state. There

had not been any associated pain. His weight at this time had been 220 pounds (99.8 kg.). About one month after the onset of dysphagia he had felt a mass come up in the back of his throat after he had vomited. This mass had filled his oropharynx and he had thought that it was the back of his tongue. He had tried to swallow the mass, which he thought was about the size of a large lemon, but as he had been unsuccessful in doing this he pushed it down with his fingers. He did not know that this mass was an abnormal structure. This had been the only time that the tumor ever had come up into his throat. After this he had begun to have more trouble with gaseous eructation, sore throat, and regurgitation of undigested food. These symptoms had been particularly noticeable after meals for five years before he came to the clinic. During this time he had begun to lose weight, about one to two pounds (0.5 to 0.9 kg.) a month, and had noticed dyspnea on exertion. He had taken large quantities of liquids, from one and one-half to two quarts (1,500 to 2,000 c.c.) at a meal in order to wash the solid food down. Four years before he came to the clinic, he had had an infection of the upper part of the respiratory tract which had been diagnosed as pneumonia. A roentgenogram had disclosed a dilated esophagus. After a large quantity of decayed food matter had been removed from the esophagus by lavage and suction, he had recovered rapidly. At this time, esophagoscopy had been performed on several occasions and the cardia had been dilated several times with a mercury bulb, but this treatment had produced little or no change in the symptoms. He was of the opinion that the condition had been considered as spasm of the cardia. Because of lack of improvement in his symptoms, he had become discouraged and had not taken treatment for the next three years; however, his symptoms gradually had become worse, particularly the regurgitation of food, which had become more frequent and had increased in amount. During the nine months before he came to the clinic his diet had consisted of one to two quarts (1,000 to 2,000 c.c.) of milk and unbleached rice, but even with this type of food there had been some regurgitation after each meal. For several months he had been unable to lie down to sleep because of the regurgitation of saliva and secretion into his mouth, which had necessitated his sleeping in an upright position in a chair.

At the time of his registration at the clinic, he had lost fifty-five pounds (24.9 kg.), but in spite of this loss of weight his general condition was rather good. His weight was 165 pounds (74.8 kg.). The systolic blood pressure was 178 mm. of mercury and the diastolic pressure 125 mm. The pulse rate was 90. The value for the hemoglobin was 14.8 Gm. per 100 c.c. of blood. The erythrocytes numbered 5,010,000 and the leucocytes 6,000 per cubic millimeter of blood, respectively. The results of urinalysis were essentially negative. The value for the blood urea was normal.

Roentgenologic examination of the esophagus revealed great dilatation and hypertrophy of the esophagus but no serious delay at the

cardia. No tumor was visualized; therefore, it was believed that the symptoms probably were due to cardiospasm (Fig. 1). Esophagoscopy revealed a large pedunculated intraesophageal tumor covered with normal esophageal mucosa. The tumor was attached by a pedicle to the upper end of the esophagus immediately below the cricoid cartilage and extended down to the cardia. Operation was imperative because of the severity of the dysphagia and the inability to obtain sufficient nourishment. Because of the large size of the tumor, which not only filled the entire esophagus but pushed the dilated esophagus into the right thoracic cavity, it was thought that a transpleural esophagotomy would be the most effective method of approaching and removing the tumor.

Fig. 1.—Great dilatation and displacement of the esophagus into the right thoracic cavity (Case 1); roentgenoscopy did not disclose any delay at the cardia; the cardia was patent and the stomach was normal.

Nov. 20, 1943, one of us (S. W. H.) performed a right transpleural esophagotomy and removed the tumor completely by utilizing a posterolateral incision with resection of the posterior two-thirds of the fifth rib and removing 2 cm. of the angles of the fourth and sixth ribs. The pleural cavity was opened by incising the pleura through the posterior periosteum of the sixth rib. This exposed an enormously dilated esophagus which had a thick wall. An esophagotomy was performed above the azygos vein and it was necessary to make an incision from 12 to 15 cm. long in the esophagus to remove the large tumor. The pedicle,

which was at the introitus, was cut between clamps and ligated. There was no other attachment of the tumor to the wall of the esophagus (Fig. 2). The tumor was removed completely. The esophagus was then closed with one continuous silk suture and two rows of interrupted silk

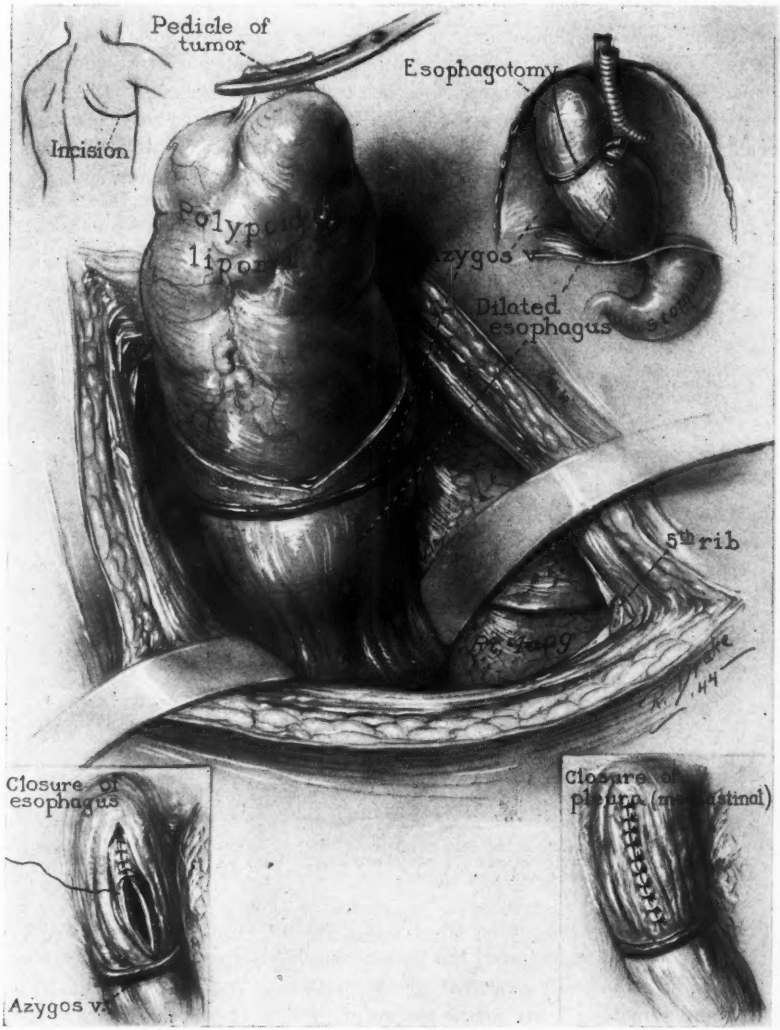
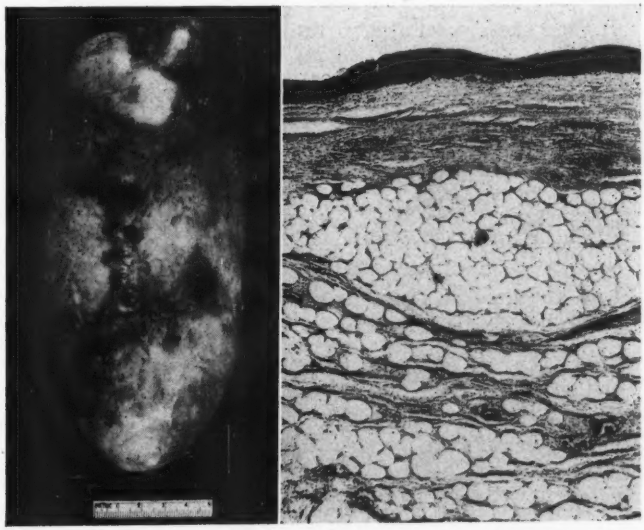


Fig. 2.—Transpleural esophagotomy for complete removal of pedunculated polypoid lipoma which was attached at the introitus of the esophagus (Case 1). The tumor caused a marked dilatation and displacement of the esophagus, filled the entire lumen and extended to the cardia. Left insert shows posterolateral incision. Upper right insert shows marked displacement and dilatation of the esophagus and the site of the incision of the esophagus above the azygos vein. Lower left insert shows closure of esophagus by using a continuous inverting suture of silk. Lower right insert shows the completion of the closure of the esophagus and overlying mediastinal pleura with interrupted silk sutures.

sutures. The mediastinal pleura was sutured over the line of closure in the esophagus. The pleural cavity was irrigated with saline solution and 10 Gm. of sulfathiazole were placed in the pleural cavity. The lung was inflated with positive pressure and closed drainage of the pleural cavity was instituted through the periosteum of the fifth rib, anteriorly.

The tumor was 22 cm. long and 8.5 by 5.5 cm. wide. It was covered with normal mucosa. On microscopic examination it was found to be a polypoid lipoma (Fig. 3, *A* and *B*).



A. *B.*

Fig. 3.—*A*, Large polypoid lipoma covered with normal esophageal mucosa which is ulcerated in places (Case 1); *B*, section of tumor (×32).

The patient's immediate convalescence was very satisfactory. On the third day his temperature was 101° F. and his pulse rate increased. The leucocyte count was 9,700. The next day his temperature was 103° F. and the leucocyte count was 9,000. There was only moderate drainage from the pleural cavity through the closed drainage tube. A culture of the material draining from the pleural cavity revealed green-producing streptococci. Penicillin therapy was employed. His temperature gradually dropped to 99° F. on the eighth day, and at this time open drainage of the empyema on the right side was instituted. There was a moderate-sized cavity which gradually closed.

Roentgenograms made at the time of the patient's dismissal, March 27, revealed considerable reduction in the size of the esophagus but it was still moderately dilated. The right lung had re-expanded and the empyema cavity had become completely obliterated. His symptoms had

disappeared completely, he had gained twenty pounds (9.1 kg.), and his general condition was very satisfactory.

CASE 2.—A man, aged 24 years, came to the clinic Aug. 7, 1940, complaining chiefly of sore throat, dysphagia, cough, pain in the thorax, and weakness. He had been perfectly well until three and one-half years previously, when he had had an acute infection of the upper respiratory tract and a severe sore throat which had persisted since that time. Difficulty in swallowing had begun about the same time. It had occurred periodically and often had disappeared for a week or more. He had had several attacks, during which he had been unable to swallow any food for a day or more at a time, and he always had had to wash his food down with large quantities of water. He had had a cough which had been productive of clear mucus which had seemed to accumulate in his throat. This had been more severe when his throat had been very sore. At times, he had noticed bloodstreaked sputum. There was a questionable history of melena. He had had attacks of vomiting which had been associated with a choking sensation in his throat and retrosternal pain. On four occasions a mass had been coughed up and nearly had strangled him when it had protruded from his mouth. This first had occurred in the course of a vomiting spell. He had attempted to bite the tumor off but had been unable to do so. He had replaced it in his mouth and had swallowed it. Regurgitation of the tumor had not occurred recently but he had had increasing difficulty with regurgitation of food, progressive loss of weight, and weakness. He had had several examinations both roentgenologically and esophagoscopically before he came to the clinic and it had been thought that his condition was due to cardiospasm. The presence of a tumor had not been recognized.

At the time of his visit to the clinic, his general condition was rather good. He had lost about fifteen pounds (6.8 kg.). The value for the hemoglobin was 6.6 Gm. per 100 c.c. of blood. The erythrocytes numbered 4,080,000 and leucocytes 8,200 per cubic millimeter of blood, respectively. Roentgenologic examination of the esophagus revealed severe dilatation with lagging at the cardia. A diagnosis of cardiospasm was made (Fig. 4). Examination of the stomach did not disclose any abnormality. Esophagoscopic examination revealed a large pedunculated esophageal tumor which was attached to the posterior wall of the esophagus just below the cricoid cartilage. The tumor extended down into the middle third of the esophagus. An attempt was made to bring the tumor out of the esophagus but this was impossible because the tumor was tightly wedged into the esophagus. In addition, the patient had an associated cardiospasm. Operation was necessary not only because of the presence of a tumor but because it was producing progressive dysphagia which resulted in an inability to obtain sufficient nourish-

ment. Because the pedicle of the tumor was found to be in the introitus and the tumor was of moderate size, it was decided that cervical esophagotomy would be the best method of approach for removal of the tumor.

Aug. 14, 1940, one of us (S. W. H.) performed a cervical esophagotomy by approaching the tumor from the left cervical region. An incision was made along the anterior border of the left sternomastoid muscle. The carotid and jugular vessels were retracted to the left, and the left inferior thyroid artery and vein were ligated. Elevation of the thyroid gland exposed the esophagus, which was markedly dilated and edematous. A longitudinal incision was made into the lateral wall of the esophagus. The esophagus was explored and it was found that there

Fig. 4.—Dilatation of esophagus originally thought to be due to cardiospasm (Case 2); esophagoscopy revealed a pedunculated tumor of the esophagus.

were two tumors, each with a pedicle originating from a single pedicle in the introitus of the esophagus (Fig. 5). The single pedicle of origin was cut between clamps and ligated. The tumor was completely removed through the esophagotomy wound. The incision in the lateral wall of the esophagus was closed with one layer of interrupted catgut sutures, which approximated the mucosa, and with two layers of interrupted silk sutures which closed the wall of the esophagus.

One tumor measured 10 by 5.5 cm. and the other 7.5 by 3.5 cm. The two tumors had a pedicle 6 cm. in length and were attached to the esophagus by one pedicle (Fig. 6 *A* and *B*). Microscopic examination dis-

closed that the tumors were myxofibromas. They were covered with normal esophageal mucosa which was ulcerated over much of the surface of each tumor. This undoubtedly accounted for the bleeding which had occurred and also for the secondary anemia which had been present before operation.

The convalescence was uneventful and the patient was dismissed Sept. 16, 1940, at which time the wound had healed entirely. His general condition was very good and he had been entirely relieved of symptoms. In a recent letter, he stated that he had not had any recurrence of his former symptoms.

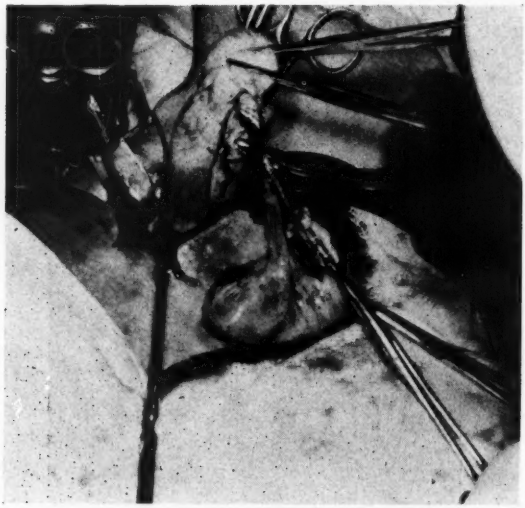


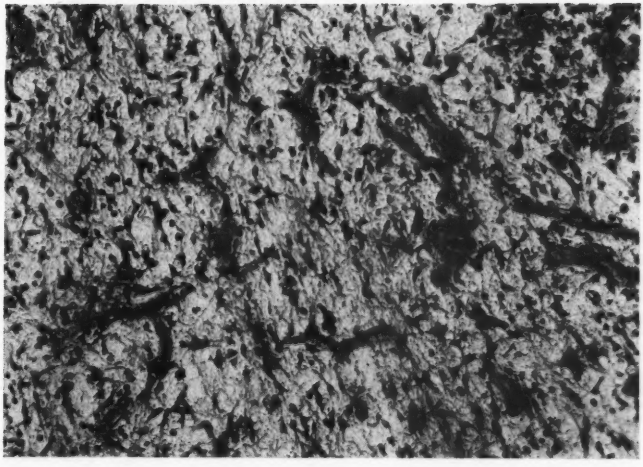
Fig. 5.—Left cervical esophagotomy for removal of two pedunculated tumors (myxofibromas) originating from a single pedicle at the esophageal introitus (Case 2).

CASE 3.—A woman, aged 56 years, came to the clinic May 17, 1943. Her chief complaint was pain beneath the xyphoid, of one month's duration. She had not had any symptoms prior to one month previously, when she had noticed pain beneath the lower part of the sternum and xyphoid cartilage, which had been moderately severe. The pain, which had been localized to this region, had lasted from five to ten minutes. It often had been present when she had arisen in the morning and it had been present at irregular intervals throughout the day. Heat on some occasions had relieved the pain. Food or swallowing had not had any effect on producing or relieving the pain. She had not had any difficulty in swallowing solid food and had not regurgitated her food. She frequently had been annoyed by a gagging sensation which had been associated with regurgitation of a small amount of mucus. She had been treated for anemia for three years and there had been some suspicion that the anemia was of a pernicious type but this diagnosis had not been

established definitely. The anemia always had responded well to treatment with liver extract.

The patient weighed 133 pounds (60.3 kg.), which represented a loss of ten pounds (4.5 kg.). The blood pressure was 180 mm. of mercury, systolic, and 95 mm. diastolic. The value for the hemoglobin was 13.1

A.



B.

Fig. 6.—*A*, Pedunculated tumors arising from the esophageal introitus (Case 2); *B*, section of one of the tumors showing a myxofibromatous structure (×125).

Gm. per 100 c.c. of blood. The erythrocyte count was 5,030,000 and leucocyte count was 8,500. A roentgenogram of her thorax revealed a tumor mass lying to the right and behind the lower part of the esophagus and cardia of the stomach. The mass apparently extended through the

esophageal hiatus. A roentgenogram of the esophagus and stomach showed a lesion involving the distal portion of the esophagus and the cardia (Fig. 7). There was a large extrinsic mass which appeared to lie sometimes in the thorax and sometimes in the abdomen, as though it slipped back and forth through the hiatus. There also was a duodenal ulcer with a shallow crater. Esophagoscopic examination revealed an obstruction at the lower end of the esophagus owing to a tumor which involved the wall of the esophagus and pushed the esophagus posteriorly

Fig. 7.—Esophageal tumor extending through esophageal hiatus and obstructing lower part of the esophagus at the cardia (Case 3).

and to the left. The mucous membrane of the esophagus was normal and intact and there was no lesion of the cardia of the stomach. A diagnosis of a probable intramural leiomyoma was made. Although there was no history of dysphagia, operation was advised because of the large tumor which was disclosed by roentgenography and because of dilatation of the esophagus above the tumor. An abdominal approach was employed because a considerable portion of the tumor protruded through the hiatus into the abdomen.

May 13, 1943, operation was performed by one of us (S. W. H.). A left rectus incision was employed. A large leiomyoma was found involving the lower part of the esophagus; the greater portion of the tumor was in the posterior mediastinum and extended through the hiatus into the abdomen (Fig. 8). The tumor was removed and the opening in the lower part of the esophagus and cardiac end of the stomach was repaired

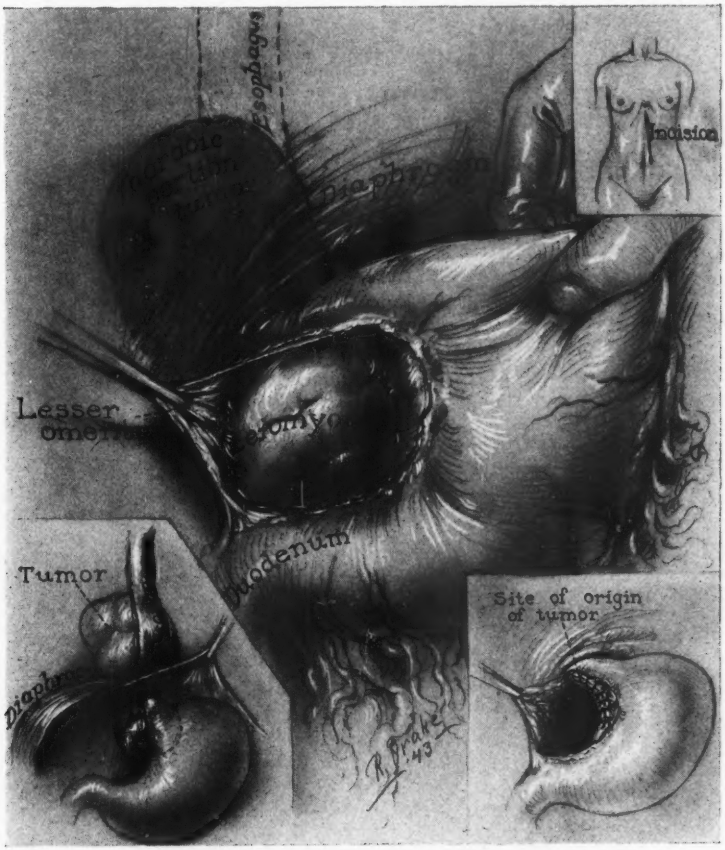


Fig. 8.—Large leiomyoma of the right wall of the lower part of esophagus and cardia extending through and enlarging the esophageal hiatus and partially obstructing the esophagus at the cardia (Case 3). Tumor was removed through an oblique left rectus incision. Esophagus and cardia were repaired with interrupted silk sutures.

with interrupted silk sutures. A small portion of the tumor, which extended deep into the posterior mediastinum, was not removed because of its fixation to the pericardium. It was felt that this would undergo atrophy. If not, it could be removed later. Microscopic examination revealed a leiomyoma. The tumor measured 15 by 7 cm. and weighed 190 Gm. (Fig. 9, *A* and *B*). The patient's convalescence was uneventful.

A. *B.*

Fig. 9.—*A*, Large leiomyoma removed from lower part of esophagus (Case 3); *B*, section of tumor (×70).

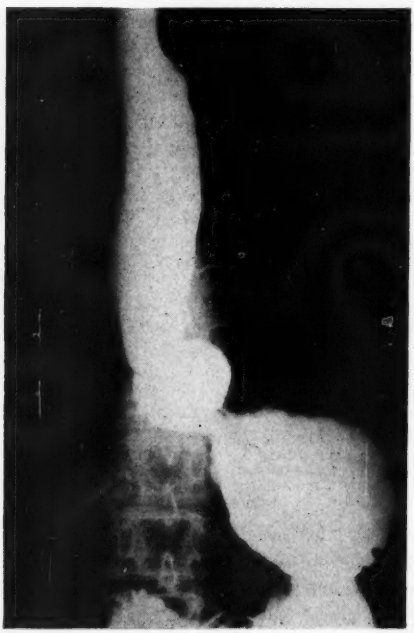


Fig. 10.—Roentgenogram made five months after operation in Case 3; esophagus is normal. (Small esophageal hiatus hernia resulting from the enlargement of the esophageal hiatus by the tumor.)

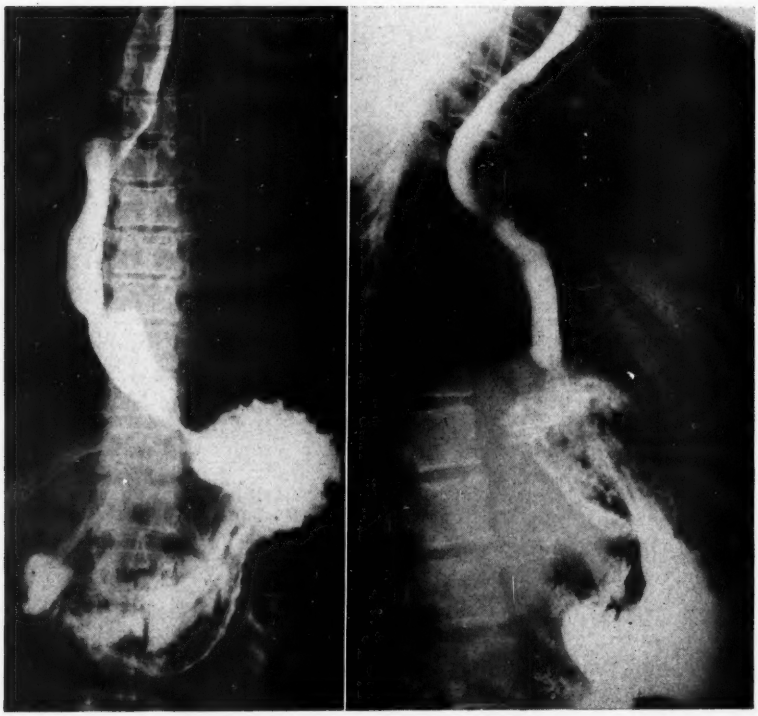
She was dismissed from our care June 21, 1943, at which time the wound had healed entirely and her general condition was very good. A roentgenogram showed slight deformity of the lower end of the esophagus (Fig. 10). She had no subjective symptoms. She was advised to return for observation in three months. When she returned, Oct. 26, 1943, she had no subjective symptoms. Her appetite had been very good. She had had no dysphagia. As her blood pressure had increased to 210 mm. of mercury, treatment for hypertension was instituted. A roentgenogram showed a very slight deformity of the lower end of the esophagus which was much less pronounced than it had been at the time of her dismissal; this indicated atrophy of the residual portion of the tumor in the posterior mediastinum. In view of the fact that her progress has been very satisfactory, we do not believe it will be necessary to remove the remaining portion of the tumor; however, she will be kept under observation.

CASE 4.—A woman, aged 39 years, came to the clinic March 8, 1943, complaining of cough of fifteen years' duration. During this time she had had periodic attacks of cough in the winter. The cough had been continuous throughout the cold weather but had been much less noticeable in the summer. It had been relatively nonproductive until about three months before she came to the clinic, when she had had severe colds associated with chills, fever, and expectoration of purulent material. Since that time she had had a constant hacking cough with moderate dyspnea, and a short time before she came to the clinic she had noticed some diffuse substernal pain on swallowing. She had not had any dysphagia.

When the patient was examined at the clinic, the systolic blood pressure was 105 mm. of mercury and the diastolic pressure was 74 mm. A roentgenogram of her thorax showed that the lung fields were essentially normal. There was a large rounded soft tumor mass in the posterior mediastinum. There was some compression of both main bronchi and some widening of the angle of the coryna. A roentgenogram showed a tumor, approximately 5 by 8 cm., lying posterior and to the right of the middle third of the esophagus (Fig. 11, *A* and *B*). The tumor was compressing the lumen of the esophagus and probably had originated in the wall of the esophagus. On bronchoscopy, the coryna was found to be greatly flattened. The right main bronchus was displaced laterally and the lumen was reduced to approximately one-half its normal diameter owing to pressure on the medial wall. The left main bronchus was displaced further to the left than normal. Esophagoscopy revealed that the esophagus was displaced to the right by a mass at the level of the middle third. The mucous membrane was intact.

March 7, a right transpleural mediastinotomy was performed by one of us (S. W. H.). A posterolateral incision was made and the posterior

two-thirds of the fifth rib were resected. The pleural cavity was opened through the posterior periosteum of this rib and a large tumor was found in the anterior wall of the esophagus. The tumor was very adherent to the right and anterior portions of the pericardium. It projected between the two main bronchi, to which it was very adherent. The right bronchus had been compressed more than had the left bronchus. It was difficult to determine the site of the esophagus posteriorly. A large stomach tube was passed through the esophagus to determine its position.



A. *B.*

Fig. 11.—Tumor of anterior wall of the middle third of the esophagus (Case 4); tumor is displacing the esophagus to the right and posteriorly; *A*, anteroposterior view; *B*, lateral view.

The tumor was very adherent to all of the surrounding structures. It was removed completely (Fig. 12). The tumor was very friable and degenerated in the central portion. There was some necrosis of tissue. The tumor contained about six ounces (180 c.c.) of thick necrotic puslike material. The esophagus was reinforced with interrupted silk sutures at the site of removal of the tumor. The lumen of the esophagus was not opened. The thoracic cavity was irrigated with physiologic salt solution. Ten grams of sulfathiazole were placed in the pleural cavity,

which was drained with a 24 F. catheter. Microscopic study of the tissue revealed an infected cyst that was lined with glandular epithelium and contained smooth muscle in its wall.

The patient made an uneventful convalescence. The highest temperature was 100° F. on the fourth day. The temperature then dropped to normal and remained normal until her dismissal on the twenty-third

Fig. 12.—Cystic tumor originating from the anterior wall of the middle third of the esophagus (Case 4), displacing the esophagus to the right (and posteriorly), causing marked compression of the right main bronchus, moderate compression of the left main bronchus, and widening of the corynal angle. Tumor is adherent to the right portion of the pericardium. Upper right insert shows posterolateral incision for transpleural removal of tumor. Left lower insert shows repair of esophagus at the site of the tumor.

day, at which time the wound had healed entirely. She had been relieved entirely of the cough and had no subjective symptoms. Roentgenograms of the thorax were essentially normal at this time. When she returned for observation six months after operation, her general condition was very good. She had not had any recurrence of dyspnea. She stated that occasionally dry food would stick in the upper part of her esophagus. Esophagoscopic examination revealed a slight herniation of the esophagus wall at the point of removal of the tumor and slight narrowing of the esophagus below this region.

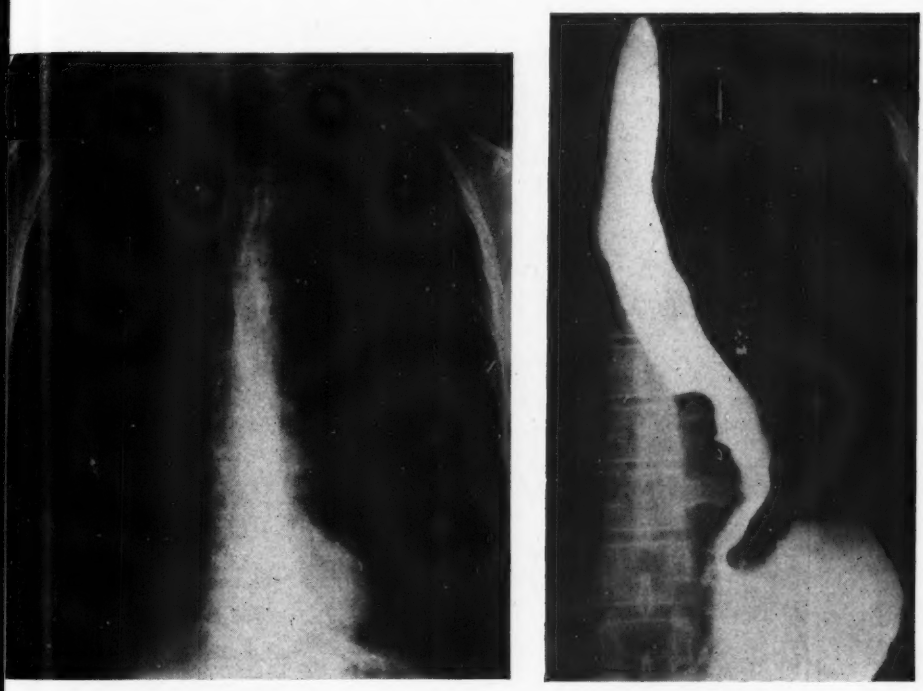
CASE 5.—A man, aged 39 years, came to the clinic May 18, 1942, complaining of asthma, bronchitis, hay fever, nervousness, and fatigue, of four months' duration. He had had asthmatic bronchitis and hay fever for twenty years. About four months before he came to the clinic he had begun to feel extremely tired and had become fatigued after work; he had had dizzy spells, particularly when walking, and had had sensations of falling and many other nervous symptoms.

The results of physical examination were essentially negative except for emphysema and râles throughout both lungs. The results of all laboratory tests were essentially negative except that roentgenologic examination of the thorax revealed some emphysema and a shadow of increased density behind and a little to the left of the heart (Fig. 13*A*). It was felt that this probably was due to a diaphragmatic hernia. A roentgenogram of the stomach and esophagus revealed a deformity of the lower end of the esophagus just above the cardia (Fig. 13*B*). The patient had not had any dysphagia.

Esophagoscopic examination showed a marked deformity of the lower end of the esophagus which extended to a point fourteen and one-half inches (40.6 cm.) from the incisor teeth. The esophagus was angulated to the left. There was no obstruction at the cardia and the action of the sphincter seemed to be gone. There was some irritation of the mucous membrane owing to regurgitation of gastric secretion. The mucous membrane was intact. There was no indication of a tumor which would permit biopsy. Because of the many general symptoms and relatively poor general condition of the patient, neither of which was related to the esophageal tumor which had been discovered in the course of a previous examination, operation was not advised. General supportive treatment was employed for the general symptoms.

When the patient returned to the clinic after an absence of three months, his general condition was somewhat improved and he had no symptoms referable to the tumor, which had not changed in size. He was advised to continue with the general treatment. When he returned again, May 2, 1943, his general condition had improved considerably but he was greatly worried over the presence of the tumor. Complete examination, including roentgenographic studies (Fig. 13*B*) and esophagoscopy, disclosed no appreciable change in the size of the tumor;

however, because of his anxiety in regard to its presence and owing to the fact that his general condition had improved, we felt justified in advising surgical treatment. At this time, the value for the hemoglobin was 17 Gm. per 100 c.c. of blood. The erythrocyte count was 4,446,000 and the leucocyte count was 8,600. The value for the blood urea was normal. Urinalysis did not reveal any abnormality.



A. *B.*

Fig. 13.—*A*, Roentgenogram of thorax, made when the patient in Case 5 first came to the clinic, showing emphysema of lungs and increased density behind the cardiac shadow; *B*, a subsequent roentgenogram disclosed that this increased density was due to a tumor of the lower part of the esophagus. One year later, when the patient returned to the clinic, the appearance of the esophagus in the roentgenogram was the same as it was in *B*.

June 12, 1943, the tumor was exposed by a left transpleural incision. The lower fourth (17.8 cm.) of the esophagus and the cardiac end of the stomach were resected. A left posterolateral incision was made and a portion of the eighth rib was resected. The tumor involved the entire wall of the lower 5 inches (12.7 cm.) of the esophagus. It extended down to the cardia of the stomach. The tumor was very lobulated and the structure of the wall of the esophagus was not normal. It was necessary to make a transdiaphragmatic incision at the lower end of the tumor at the cardia. The upper end of the stomach was closed and the esophagus was anastomosed to the anterior wall of the stomach. The

cardiac end of the stomach was transposed into the thoracic cavity and an esophagogastrostomy was performed (Fig. 14).

Microscopic examination revealed a leiomyoma which completely surrounded and compressed the esophagus (Fig. 15).

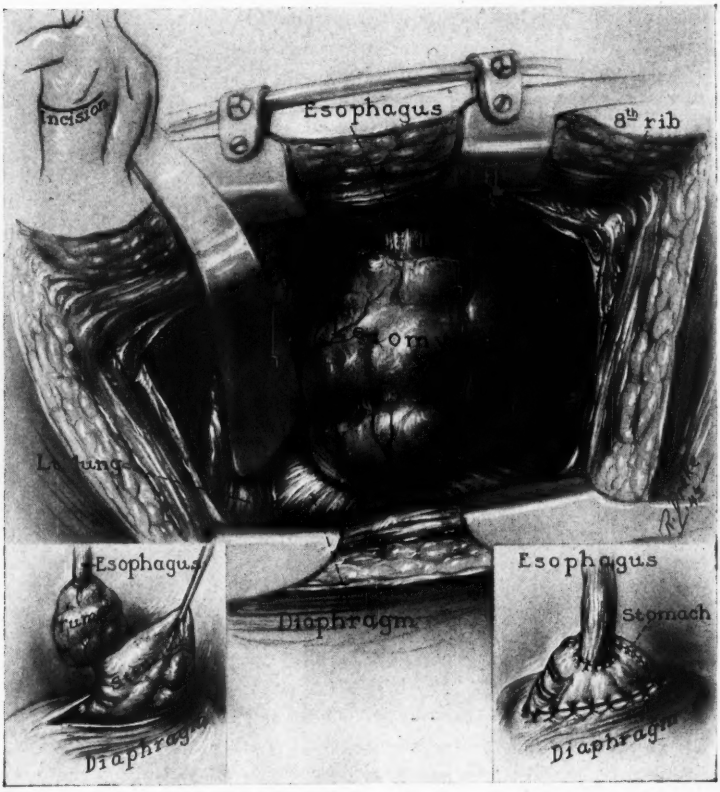
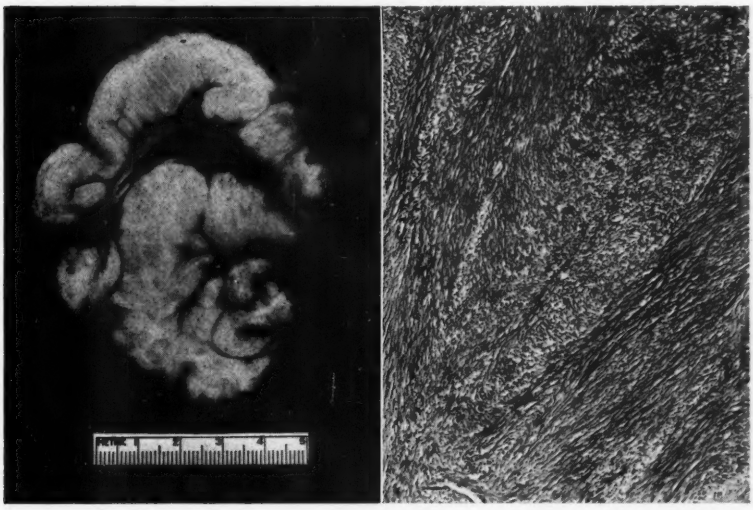


Fig. 14.—Resection of lower fourth of esophagus for removal of leiomyoma in Case 5. The stomach was transposed into the thoracic cavity (lower left insert), and the esophagus was anastomosed to the anterior wall of the stomach (lower right insert).

The immediate response to the operation was good except for an increase in the respiratory rate. The patient immediately was placed in an oxygen tent. His temperature gradually rose to 103° F. and there was an increase in his respiratory rate as well as an increase in his pulse rate. His condition became gradually worse and he died on the fourth day, of bilateral bronchopneumonia.

This is the only death which has occurred in removal of benign tumors of the esophagus and we do not believe this death was due as much to the operative procedure as it was to the previous pulmonary condition.

The patient had had asthmatic bronchiectasis for twenty years and we believe it is questionable whether or not he should have been subjected to surgical treatment for two reasons: first, because he had been refused operation on two previous occasions, and second, because of his poor general condition as well as the fact that we did not believe the tumor was responsible for his symptoms.



A. *B.*

Fig. 15.—Intramural leiomyoma involving entire wall of esophagus but not involving mucous membrane; *A*, gross appearance; *B*, section of tumor (×70).

Case 6.—A man, aged 62 years, came to the clinic Nov. 20, 1921. Six years previously, he had coughed and raised into his mouth what seemed to be a small growth attached to the palate; he had swallowed the growth again. His throat had been swollen and sore for five days thereafter. He had thought that the growth was an enlarged palate. Three weeks before he came to the clinic, he had eaten too much and had vomited and brought up a piece of tissue long enough to protrude from his mouth. He again had swallowed the tissue which was the size of his little finger. Two weeks before he came to the clinic he had experienced the same thing on two occasions and had felt a tickling sensation in his throat. He had had no difficulty in swallowing.

An esophagoscopic examination revealed a long, narrow, pedunculated tumor extending down the esophagus. The tumor was situated on the right wall of the esophagus about one and one-half inch (3.8 cm.) below the introitus. No attempt was made to pull it up.

Dec. 7, 1921, Dr. E. S. Judd operated upon the patient through a left cervical incision in the anterior border of the sternomastoid muscle. Esophagotomy was performed and the tumor was excised at the base of

the pedicle. The esophagus was closed with two rows of catgut sutures and one row of interrupted silk sutures. Microscopic examination revealed that the tumor was a lipoma.

He was dismissed from the clinic Dec. 21, 1921. In letters which have been received from his home physician, March 27, 1922, and from his wife, May 8, 1922, it was learned that he had had gastric symptoms and had been unable to eat ever since he returned home. We have had no further record of his condition.

CASE 7.—A man, 71 years of age, came to the clinic March 1, 1944, because he had regurgitated a fleshy mass into his mouth. Ten or twelve years previously the patient first had noticed, after a coughing spell, a lump on the back of his tongue. He had attempted to cough this out but had been unsuccessful; after a few moments, it had slipped away. Three weeks later, the same thing had occurred. Seven years before the patient came to the clinic, he again had regurgitated the mass and this time it had reached as far as his teeth. Three years before his admission, after a vomiting spell, the tumor again had reappeared and had projected from the mouth. At this time, he had attempted to bite off the tumor without success, and again had swallowed it. Roentgenography and esophagoscopy had disclosed a benign pedunculated tumor of the esophagus. Operation was advised but refused.

When the patient was examined at the clinic, the previous diagnosis of a pedunculated, benign esophageal tumor was confirmed. Roentgenologic examination of the esophagus demonstrated the lesion, which appeared attached to the left wall of the esophagus. Esophagoscopy revealed a pedunculated tumor which extended down into the middle third of the esophagus and was attached by a pedicle to the left lateral wall of the esophagus just below the level of the cricoid cartilage. The lower end of the tumor was grasped with forceps and the tumor was brought out of the mouth. A snare was slipped over the tumor and, under esophagoscopic guidance, placed about the base of the pedicle. The pedicle was then severed with a cutting current in order to prevent bleeding. The patient made a rapid and uneventful recovery. Microscopic examination revealed that the tumor was a polypoid fibrolipoma.

(*See discussion on page* 423.)

CAUSES OF MORTALITY FOLLOWING RADICAL RESECTION OF THE ESOPHAGUS FOR CARCINOMA

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PROGRESS in the surgery of the esophagus has been so rapid and satisfactory during the past ten years that most surgeons are now agreed that the treatment of choice for malignant disease of this organ is by radical surgical methods. It seems to me that there can be no quarrel with the statement that this rapid progress has been made possible by, and has probably been synchronous with, the development of thoracic surgery and the advancements in the field of anesthesiology. Not until the surgeon began to understand the disturbances in respiratory and circulatory physiology incident to open thoracic procedures did he direct his attack to the esophagus, an organ which, only a few years ago, was considered quite beyond the scope of all except the rarely courageous and venturesome pioneer. However, in spite of the debt owed to thoracic surgery, I am of the opinion that the pure thoracic surgeon should not undertake the surgical treatment of cancer of the esophagus unless he is fully conversant with, and has had experience in, the modern suture methods employed in the surgery of the gastrointestinal tract. All other factors being equal, the success of radical procedures applied to the esophagus is concerned mainly with the proper application of these methods.

On the basis of a diversified experience all over the country, there is general agreement now that the procedure of choice for neoplasms of the distal third of the esophagus and adenocarcinoma of the cardia is a left transthoracic resection of the cancer-bearing focus with all the associated lymph nodes, and an intrathoracic esophagogastric anastomosis. Because of the frequency of lymph node involvement below the diaphragm and the possibility of hepatic metastases with adenocarcinoma, I would like to stress again the advisability of a preliminary abdominal exploration to determine operability. This relatively innocuous procedure will often spare the patient a needless thoracic exploration. At the same time, the surgeon may add a jejunostomy for feeding purposes, should adjuvant feeding of this type be deemed necessary.

Up to 1943, the operation of choice for neoplasms of the middle third of the organ was the modified Torek procedure, which consisted of a

From the Surgical Service of the Mt. Sinai Hospital.
Read at the Twenty-fifth Annual Meeting of the American Association for Thoracic Surgery, Chicago, Ill., May 5 and 6, 1944.

resection of the entire thoracic esophagus by either a left or right approach, the formation of a lower esophagostomy on the upper abdomen and exteriorization of the upper esophagus on the anterior chest wall. Artificial continuity was established by a rubber tube connecting the upper and lower esophagostomy stomas. In a number of instances, it was possible subsequently to fashion a skin-lined tube beneath the skin of the anterior chest wall to take the place of the excised organ. While, from the standpoint of good cancer surgery, the Torek operation was radical, it left the patient with an artificial substitute that was distasteful and subject to all sorts of mechanical difficulties. About May, 1943, I discarded the Torek procedure in favor of a different operation which was reported in January of this year. On the basis of an experience with two patients, I believe it is feasible to bring the stomach over the arch of the aorta and anastomose it to the esophagus near the apex of the chest, without jeopardizing the blood supply of either organ and without producing any unusual disturbances by placing the stomach in so abnormal a situation. The first patient has been well for one year and is quite free of symptoms. The other was too recent to warrant definitive comment. It has been clear to all of us, however, that the postoperative course has differed in no way from that seen in patients with an anastomosis below the arch of the aorta.

During the eight years covering the period of this study, we have intentionally accepted for operation every patient who presented a reasonable chance of surviving this extensive and often very difficult procedure. We have not rejected any patient because of age or associated medical complication unless it was obvious to all concerned that the individual was a hopeless surgical risk and could not possibly survive. It might be added that there were very few in this category. It is our conviction that, with an otherwise hopeless disease, all risks should be taken and that the patient should not be denied the possibility of recovery and relief of his ailment. Perhaps our judgment has been faulty in this respect. Certain it is that, if a careful selection of cases had been made, the total operative mortality would have been considerably lower. However, we have been anxious to obtain an appraisal of the over-all picture of the surgical treatment of this disease as applied to all age groups and, as a result of this viewpoint, many important facts have been uncovered which might otherwise have not been recognized.

In analyzing the entire series, I have divided them into two categories: (1) adenocarcinoma of the cardia with esophageal involvement and (2) squamous cell carcinoma. In the first group exploration was done in 66 cases; 31 patients were found operable and in each instance a transthoracic resection and anastomosis was performed. There were 16 operative deaths and 15 recoveries, a mortality percentage of 51.6. In the squamous cell group, exploration was carried out in 65 patients

and 29 were found operable. In 15 patients, the Torek operation or a modification of it was performed. In 14, an intrathoracic anastomosis was carried out. There were 13 deaths and 16 recoveries, a mortality of 44.8 per cent. Combining the two groups, exploration was carried out in 131 patients and 60 were found operable. The over-all operative mortality was 48.3 per cent (Table I).

TABLE I

Adenocarcinoma of Cardia	
Total number explored	66
Operable	31
Inoperable	35
Operative deaths	16
Recoveries	15
Operative mortality	51.6%
Squamous Cell Carcinoma	
Total number explored	65
Operable	29
Inoperable	36
Operative deaths	13
Torek operation and anastomosis	
Operative mortality	44.8%
Recoveries	16
Torek operation and anastomosis	
Combined Groups	
Operable cases	60
Deaths	29
Mortality	48.%

Analysis of the 29 operative deaths discloses some interesting facts. There were 25 men patients and 4 women. The ages varied between 42 and 73 years. The average age was 61+. The vast majority were in none too robust condition. In addition to the disturbances caused by starvation and dehydration, many presented complicating medical conditions such as diabetes, emphysema, myocardial disease and arteriosclerosis. Although every effort was made to overcome the various nutritional deficiencies and to minimize the medical complications over preoperative periods varying from one to four weeks, it is clear that the associated complicating factors played a major role in the death of the majority of these patients.

In analyzing the causes of death, I have arbitrarily divided them into two groups: (1) Those due to preventable causes (Table II), and (2) those due to causes beyond the control of the surgeon (Tables III and IV).

In the first group there were six deaths. As indicated in Table II, the first patient died of mediastinitis and peritonitis from a leak in the esophagus one inch above the anastomosis due to injury of the muscularis at operation. The second patient developed a small perforation of the stomach on its upper anterior wall due to interference with blood supply, and died of peritonitis. The third patient died of operative

Analysis of 29 Deaths*

Table II

Deaths Due to Preventable Causes

OPERATION	DAY OF DEATH	AUTOPSY	CAUSE OF DEATH
Anastomosis	9th	Yes	General peritonitis, mediastinitis due to leak from esophagus due to trauma at operation
Anastomosis	4th	Yes	Peritonitis due to tiny perforation at upper stomach, impaired blood supply
Anastomosis	1st	No	Operative shock
Anastomosis	2nd	Yes	Herniation of cecum and terminal ileum through opening in diaphragm between two sutures with infarction of bowel
Anastomosis	1 hr.	Yes	Massive collapse of right lung due to plug in main bronchus
Torek	2nd	Yes	Tension pneumothorax of right chest; early case in series

Table III

Deaths Due to Factors Beyond Control of Surgeon

OPERATION	DAY OF DEATH	AUTOPSY	CAUSE OF DEATH
Torek	2nd	Yes	Pneumonia
Anastomosis	3rd	No	Cerebral hemorrhage, hemiplegia
Torek	1st	Yes	Cerebral hemorrhage
Anastomosis	2nd	Yes	Cerebral hemorrhage
Anastomosis	28th	Yes	Pulmonary embolus
Anastomosis	3rd	Yes	Cardiac failure
Anastomosis	2nd	No	Pulmonary edema
Anastomosis	8th	Yes	Peripheral collapse
Anastomosis	2nd	No	Cerebral hemorrhage, hemiplegia
Anastomosis	7th	No	Extensive pneumonia, positive x-ray
Anastomosis	4 hr.	No	Respiratory failure
Anastomosis	5th	No	Cerebral accident, pneumonia
Torek	7th	No	Fulminating pneumonia
Anastomosis	8th	Yes	Coronary insufficiency
Anastomosis	2½ hr.	Yes	Cause unknown, negative autopsy
Anastomosis	6th	No	Coronary thrombosis, EKG positive
Anastomosis	7th	No	Pneumonia, positive x-ray and clinical course
Modified Torek	12th	Yes	Left heart failure
Anastomosis	19th	No	Pulmonary embolus, previous phlebitis
Torek	4th	No	Cause of death not clear
Torek	11th	Yes	Cerebral hemorrhage
Torek	3rd	Yes	Coronary thrombosis, infarction post. wall
Anastomosis	4th	Yes	Pneumonia

*Twenty-five men and 4 women, ages between 42 and 73 years, majority in sixties.

Summary for Table III

Coronary Thrombosis	2
Cerebral accidents	6
Pneumonia	6
Pulmonary embolism	2
Heart failure	2
Respiratory failure and edema	2
Coronary insufficiency	1
Undetermined cause	2

shock. The tumor, located at the lower end of the esophagus, was densely adherent to the mediastinum and diaphragm. The operation was extremely difficult and tedious and required excision of part of the right mediastinal pleura. It is questionable whether the attempt at resection should have been made. The fourth patient died of an unusual complication, a herniation of the cecum and terminal ileum between two sutures anchoring the diaphragm to the transplanted stomach. This case emphasizes the importance of an accurate and careful closure of the diaphragmatic opening. The fifth death was unfortunate and preventable. The resection was quite easy and was done under intratracheal anesthesia. The patient died in great respiratory distress and at autopsy a plug was found occluding the right main bronchus. The anesthetist failed to aspirate the bronchial tree at the completion of the operation. The last patient, operated upon in 1937, died of a right tension pneumothorax. During the operation, the right mediastinal pleura was opened and I failed to aspirate the right chest at the completion of the procedure. When aspiration was finally carried out, it was too late.

Analysis of the second group indicates the importance of complicating medical conditions in determining mortality. In 12 of the 23 cases a complete post-mortem examination was made. In the remainder, the clinical course and corroborative laboratory examinations indicated the probable cause of death (Tables III and IV). The high incidence of cardiovascular accidents (13) is noteworthy. I do not think that an incidence of 6 pneumonias is unduly high.

TABLE IV

ANALYSIS OF SURVIVORS

ADENOCARCINOMA (15 CASES)	SQUAMOUS CELL (16 CASES)
4 died of recurrence 1 yr., 1 yr., 14 mo., and 1 yr. after operation	8 died of recurrence 2 yr., 20 mo., 18 mo., 11 mo., 1 yr., 16 mo., 1 yr., and 9 mo. after operation
1 died of cancer of breast 3 yr. after resection of esophagus	1 died of coronary thrombosis 3½ mo.
10 alive and doing well:	7 alive and doing well:
1, 4 yr. 2, 18 mo.	1, 8 yr. 2, 1 yr.
1, 3 yr. 1, 3 mo.	1, 5 yr. 1, 1 mo.
2, 2½ yr. 1, 6 wk.	2, 3 yr.
2, 2 yr.	

Great interest is also attached to the follow-up study of the operative survivors (Table V). In the adenocarcinoma group, 4 died of recurrence of the disease on the average of one year later. One patient died of cancer of the breast with pulmonary metastases three years after esophageal resection. Ten patients were alive and apparently free of disease from four years to six weeks. In the group of 16 patients with squamous cell cancers, 8 died of recurrence after periods varying from two years to nine months. Curiously enough, nearly every one had had a Torek operation. One patient died of coronary thrombosis three and one-half months later. Seven patients were alive and well from eight years to one month. In the entire series, therefore, there are 17 patients who are alive and apparently free of disease at the time of this communication.

This study, which has been carried on over a period of eight years, has clarified many aspects of the diagnosis and treatment of this disease and I would like to enumerate some of the important points which deserve emphasis:

1. We must forget what the old textbooks tell us that cancer of the esophagus is usually seen in the seventh and eighth decades. I have seen a few in the third and many in the fourth.

2. Duration of the symptoms of dysphagia cannot be used as a criterion of operability. I have noted an inoperable tumor with a six weeks' history and an operable one with one year's history. Operability is determined more by the biologic characteristics of the individual tumor as evidenced by grade of malignancy, invasiveness, and rapidity of spread to regional and distant lymph nodes.

3. Boring pain in the back has serious connotations and usually indicates tumor fixation posteriorly. This may or may not be accompanied by local shock tenderness.

4. The extent of weight loss is a variable factor. Those tumors which impinge early on the esophageal lumen cause rapid weight loss, a considerable part of which may be due to dehydration. Some patients with extreme weight loss have regained a pound a day during the preoperative period by parenteral hydration and were found to have removable growths. Others with minimal or no weight loss have presented inoperable tumors by reason of the fact that growth was in a peripheral direction.

5. The finding of a smooth conical obstruction at the lower end of the esophagus in the x-ray picture does not necessarily indicate a benign cardiospasm. Esophagoscopy must be carried out. Negative esophagoscopic findings do not exclude completely the presence of a cardial carcinoma. Repeated endoscopic examinations are indicated if the symptoms persist.

6. No patient should be subjected to operation unless the biopsy specimen obtained by esophagoscopy shows carcinoma.

7. The finding of squamous cell tumor in the biopsy specimen indicates origin in the esophagus. When adenocarcinoma or mucous cell carcinoma is reported, the evidence is clear that the tumor originated at the cardiac end of the stomach. I have never encountered an instance of carcinomatous degeneration of misplaced gastric mucosa in the esophagus. Every case of adenocarcinoma of the esophagus, no matter how far up the organ, has been found to have its origin at the cardia. It is important to determine the histologic characteristics of the tumor because the surgical approach is different in each instance.

8. Every patient who is a candidate for radical surgery of the esophagus must have a careful appraisal of his physical and physiologic status. This should include a thorough physical examination, electrocardiography, vital capacity determination, renal function studies, and careful attention to the condition of the teeth and gums.

9. The importance of a careful rectal examination in cases of adenocarcinoma of the cardia cannot be overemphasized. The finding of a rectal shelf indicates inoperability. The presence of enlarged firm lymph nodes in the neck, especially in the supraclavicular region, demands biopsy to exclude peripheral metastases. Hoarseness with cancers of the middle third calls for laryngeal examination. Paralysis of the left recurrent nerve indicates invasion by tumor and probable inoperability.

10. In the preoperative preparatory period, the value of intravenous hydration by saline and glucose, plasma, whole blood, and amino acids has been amply demonstrated.

11. The necessity of a preliminary gastrostomy has been completely obviated because the presence of a gastrostomy interferes with mobilization of the stomach in the performance of an intrathoracic anastomosis. Should adjuvant alimentary feeding be indicated, jejunostomy is more logical and preferable.

12. The need of an expert anesthetist for this operation requires no emphasis. We have used a combination of avertin and controlled positive pressure ethylene and ether inhalation anesthesia, and have not been impressed with any superior virtues of intratracheal anesthesia.

13. There are many details of the operative management which merit emphasis. Complete hemostasis, avoidance of operative trauma, and unhurried manipulative procedures make for a smoother convalescence, decreased morbidity, and greater chance of recovery. In mobilizing the esophagus, great care should be exerted to avoid injury to the external musculature of the organ. Any accidental tear should be carefully repaired with fine silk. Otherwise a spontaneous perforation may occur postoperatively. The growth may be found locally inoperable by reason of fixation to the aorta, vertebral column, or hilus of either lung. Invasion of the right mediastinal pleura does not necessarily indicate inoperability because it may be possible to excise part of this

pleura and bring the patient safely through the operative ordeal. There is no question but that the accidental opening of the right pleural cavity confronts the patient with a serious physiologic disturbance and greatly increases the risk of the operation. However, if tumor tissue must be excised, the surgeon has no other choice but to perform as radical an operation as is possible. The opening in the right pleura may be effectively closed by using the transplanted stomach, but the surgeon must not fail to aspirate the right side of the chest at the completion of the procedure in order to remove trapped air and thus prevent a tension pneumothorax. In mobilizing the stomach for transplantation, great care should be exerted to maintain an adequate blood supply. This is particularly applicable when an anastomosis above the aortic arch is contemplated. The same applies to the stump of the ablated esophagus, an organ which has a precarious blood supply at best. I want to stress particularly the need for a careful and accurate suture anastomosis between esophagus and stomach. This requires interrupted silk sutures, accurately placed and tied without tension, careful approximation of mucosa to mucosa and telescoping of stomach over the suture line to obviate tension and drag. We have not encountered one instance of leakage from the line of anastomosis and attribute this solely to the importance that we have attached to this part of the operation.

Another important point is the need for a careful repair of the diaphragm and fixation of its cut edge to the wall of the transplanted stomach to prevent herniation of bowel into the chest. The diaphragm should be put at rest by pinching the phrenic nerve. The local use of sulfonamides to minimize mediastinal and pleural infection has considerable merit. We have had no cause to regret the routine employment of underwater drainage of the pleural cavity in the postoperative period.

14. All patients are placed in an oxygen tent at the completion of the operation.

15. No swallowing is permitted for four or five days. If a careful anastomosis has been made, it is unnecessary to extend this for a longer period.

16. The surgeon must always be on the lookout for postoperative chest complications, such as encapsulated accumulations of air and fluid, infection of the pleural cavity, bronchial obstructions, etc. This requires daily chest examinations, bedside roentgenograms and clinical appraisal. There should be no hesitancy in employing bronchoscopy to relieve the patient of tenacious secretions. This is often a lifesaving procedure. The bedside x-ray picture may be misleading and the surgeon should, therefore, rely more on the clinical examination. Persistant dyspnea and excessive bronchial secretion usually indicate an accumulation of air or fluid or both and the surgeon should not delay aspiration.

17. Infections should be dealt with as soon as possible, because these debilitated patients cannot withstand infection for long.

It must be emphasized that the care of a patient with cancer of the esophagus is a cooperative problem requiring the concerted efforts of roentgenologist, esophagoscopist, anesthetist, operating room staff, bedside nurses, physician, and surgeon. Even under the most ideal conditions, the operative mortality is relatively high if the surgeon does not practice careful selection of his operative material. But the situation today is far different than it was fifteen years ago. Marked progress has been made and with increasing experience, I look forward confidently to a generally lower mortality and a higher percentage of cures.

DISCUSSION ON "THE MANAGEMENT OF STRICTURE OF THE ESOPHAGUS" BY DR. RALPH ADAMS AND DR. WALTER B. HOOVER;* "SURGICAL TREATMENT AND CLINICAL MANIFESTATIONS OF BENIGN TUMORS OF THE ESOPHAGUS WITH REPORT OF SEVEN CASES" BY DR. STUART W. HARRINGTON AND DR. HERMAN J. MOERSCH;† AND "CAUSES OF MORTALITY FOLLOWING RADICAL RESECTION OF THE ESOPHAGUS FOR CARCINOMA" BY DR. JOHN H. GARLOCK.

DR. RICHARD H. SWEET, Boston, Mass.—It is not proper for me to take much of your time to discuss these three interesting reports. That by Dr. Harrington and Dr. Moersch is so far out of my experience that I shall say nothing about it.

I would like to comment, however, on the interesting and valuable reports by Dr. Adams and Dr. Hoover, and Dr. Garlock. First of all I would like to suggest for your consideration that it might not be quite proper for the former to exclude so briskly the possibilities of surgical excision in some of these benign strictures.

I will show two slides, and I would like to report a case which is different in that it is an advanced, long-standing stricture in a young lad 17 years of age. The injury was received at the age of 2½ years. He spent his whole life from that time until the age of 17 entirely on a liquid diet. However, he had lost a tremendous amount of weight and was having difficulty in school, and so, having been encouraged by our relatively low mortality figures in the carcinoma group, I decided to do a radical resection of the lower portion of his esophagus.

(Slide 1.) You will see that the new stricture begins rather high, and at operation I found that there was a tongue of ulcerated esophagus which extended upward, making it necessary to divide the esophagus opposite the left main bronchus.

(Slide 2.) The next slide merely shows the x-ray result. The anastomosis you see, is rather high here. Actually it was opposite the bronchus. That boy has done exceedingly well. Now, six or seven months following operation, he is eating a normal diet with his family. This is merely a suggestion of another way in which these cases can be handled.

I was intensely interested in Dr. Garlock's report. He has certainly covered the field most admirably in every possible respect. Inasmuch as the title of the article suggests that we ought to keep to the discussion of the causes of death after operation in these cases, I will confine my remarks to that subject and will quote our experience at the Massachusetts General Hospital. Using the Torek procedure there were fourteen cases with two deaths, which makes the mortality 14 per cent. One patient died of sepsis and the other of cerebral hemorrhage.

*See page 383 for article by Adams and Hoover.

†See page 394 for article by Harrington and Moersch.

In the resection cases followed by an esophagogastric anastomosis there were fifty cases with six deaths, which makes a mortality of 12 per cent. Of that 12 per cent mortality, one patient died of shock and hemorrhage. That patient was bleeding at the time of the operation, and we knew that the time was not opportune. One died of ventricular flutter and four died of sepsis.

Just for the sake of completeness I would like to include my thirteen total gastrectomies done by the transthoracic route. In that group we were not so fortunate. There were six deaths, making the mortality 46 per cent. Two of those deaths were from massive pulmonary embolism and four from sepsis. If we add up all of these cases, the Toreks, the partial resections with esophagogastric anastomosis, and the total gastrectomies, we have seventy-seven cases with fourteen deaths or 18 per cent for the whole group.

DR. CAMERON HAIGHT, Ann Arbor, Mich.—The reports have been most interesting and instructive, but I wish to comment only on the one by Dr. Adams and Dr. Hoover in regard to the possibility of a primary anastomosis after resection of a short stricture of the esophagus. In an infant for whom a congenital atresia of the esophagus and a tracheoesophageal fistula had been repaired by ligation of the fistula and a primary anastomosis, the upper esophageal segment was shorter than usual, and the anastomosis was constructed with difficulty because of the tension that was present. A wide breakdown of the anastomosis occurred. During the healing of the wound, a complete stricture of the esophagus developed. In addition, a recurrence of a tracheoesophageal fistula, which now communicated with the esophagus above the level of the stricture, allowed secretions in the upper esophagus to enter the trachea. The problem essentially was one of closing the recurrent fistula and again attempting to obtain a satisfactory anastomosis between the two segments of the esophagus.

(Slide.) Here are shown the anatomic findings at the reoperation which was performed through an extrapleural approach three months after the primary operation. It was of interest that the lower esophagus had become dilated, undoubtedly due to regurgitation of the gastrostomy feedings into the lower esophagus. The recurrent fistula was present between the distal end of the upper esophagus and the trachea at a level of about 1 cm. above the bifurcation. The distance between the two segments was 1.5 cm. and consisted of scar tissue. At the reoperation it was possible to free the two segments of the esophagus adjacent to the stricture, to ligate and suture the recurrent fistula and to perform an anastomosis between the two ends of the esophagus. The anastomosis was constructed more readily than at the primary operation, because the lower segment had become dilated and its wall thickened. Tension was still present, however, and again the anastomosis leaked to the exterior, but the tracheoesophageal fistula remained closed.

Several attempts were made to get the infant to swallow a string for retrograde dilatations, should they be necessary, but the attempts were unsuccessful due to esophageal leak which was present at that time. Dr. Robert H. Cummings of the Urology Department was asked to introduce a cystoscope through the gastrostomy opening. It was possible for him to pass a ureteral catheter into the lower esophagus, and on advancing the catheter, it emerged from the infant's mouth. A string was tied to the catheter, and on withdrawing the catheter, the string was left through the esophagus. Retrograde dilatations were begun after subsequent spontaneous closure of the leak. The infant died one month after the reoperation as a result of malnutrition from loss of feedings around the gastrostomy tube. The lumen of the esophagus was patent, and the condition for which the reoperation had been done had been corrected.

This method of treating a complete stricture of the esophagus by an anastomosis of the esophageal segments would be applicable only in the rare event that the

stricture is quite short. A plan, such as the one Dr. Adams and Dr. Hoover have suggested, would be needed in the more frequent esophageal strictures of considerable length.

DR. FRASER B. GURD, Montreal, Canada.—Needless to say I, as well as, I believe, everyone in the room, have enjoyed and profited by the three reports on surgery of the esophagus to which we have just listened. In connection with the contribution by Dr. Harrington and Dr. Moersch on benign tumors of the esophagus I wish to show you a couple of slides which illustrate a condition which may have a bearing upon their article.

About six weeks ago, a man 64 years of age died in the Montreal General Hospital. He had suffered from carcinoma of the pleura and died of suppurative mediastinitis evidently secondary to bronchial pneumonia. As an accidental finding at autopsy, he was found to have a gizzard and it is with the suggestion that the human gizzard might simulate a benign tumor at the lower end of the esophagus that these slides are shown.

(Slides.) These pictures illustrate the lesion found. The upper third of the esophagus was normal; it was not dilated. Approximately the lower two-thirds of the esophagus were enormously thickened. This thickening, as the sections show, was due to hypertrophy of both the longitudinal and circular layers as well as the muscularis mucosae. There was no evidence of neoplasm in the wall and no lesion of the mucosa.

The case history did not indicate that during life he had suffered from any digestive or dysphagic symptoms.

I have made a somewhat careful attempt to obtain information regarding other reports of a similar lesion in the esophagus and have discussed the matter with Professor Cecil Martin of the Department of Anatomy at McGill University, without discovering any reference to a similar condition.

DR. HARRY R. DECKER, Pittsburgh, Pa.—I should like to comment briefly on Dr. Garlock's report. This subject of carcinoma of the esophagus is a very important one from the standpoint of the general medical profession, and the laity. We have been confronted up to the present time with no statistical evidence that we can cure the disease or have patients survive after any appreciable length of time.

The figures that Dr. Garlock has submitted and that Dr. Sweet has also given us this morning have a very fundamental talking point, I think, for our medical friends and for the laity with whom we have to deal.

There is only one comment I would like to make with reference to Dr. Garlock's presentation. I doubt if we ought to throw the Torek operation into discard as one might suspect he was on the point of doing. The two cases he has spoken of perhaps were not adequate evidence that we ought to throw over the radical esophageal Torek for the high-placed carcinoma.

I think it is quite important to take a survey of what type of gastrostomy should be done in these cases where we think there is potential ability to remove the growth completely. By that I mean it makes it more mechanically efficient to have only a short distance to go to complete the skin tube on the chest wall. If one will follow the teaching of Dr. Churchill and Dr. Sweet with reference to gastrostomies, he will do the Beck-Jianu type where a long tube will be brought over the costal margin, and utilize anastomosis of the cervical end and gastric end in a way to minimize the dysfunctioning of the intervening skin tube.

I am perfectly sure that wherever one is dealing with any case in which the stomach may be brought through the diaphragm for anastomosis purpose, a gastrostomy should not be done, but a jejunostomy should be done.

DR. WILLIAM F. RIENHOFF, JR., Baltimore, Md.—It has been a great privilege indeed to have heard this most interesting symposium on various lesions of the esophagus and their surgical treatment.

In the last twenty years the operative management of neoplasms and strictures of this organ has been of great interest to me. Many methods of reconstruction have been employed both experimentally and clinically. In fact I have employed all that have been described, and some that have not, with varying degrees of success.

In November, 1942, an attempt was made to reconstruct a new gullet to take the place of an esophagus which had been completely destroyed, twenty years previously, following the ingestion of lye when the patient was 2 years of age. The jejunum was mobilized by cutting across the second, third, and fourth branches of the superior mesenteric artery proximally to the loops which form the vascular comb of this portion of the small intestine. The jejunum was then divided across, first about 6 cm. distal to Treitz's ligament. Thus, approximately two and one-half feet of the gut were entirely freed from the mesenteric attachment. An end-to-side jejunojejunostomy was then performed between the short proximal end and the distal loop of jejunum at the point where the mesentery was left intact, or in other words at the lower limit of mobilization. The open end of the freed portion was closed with interrupted silk sutures. Through the upper end of the left subcostal incision employed, the midline insertions of the diaphragm to the lower end of the sternum were incised. The sternum was tunneled under by manually separating the substernal fascia from the undersurface of the sternum, remaining outside of the pleura, pericardial sac, and the anterior mediastinum. This is very easily accomplished. The mobilized loop of jejunum was then drawn up beneath the sternum to the level of the second left interspace where the free end was brought out in the subcutaneous layer beneath the skin to the level of the first interspace on the right side. At this level the closed end of the jejunum was drawn out through the skin. At a second operation the cervical esophagus was dissected free and likewise brought to the skin surface at about the level of the clavicle on the right side. The lye stricture extended so high that very little of the cervical esophagus was available for use. Thus, a hiatus of about 6 cm. existed between the opening of the esophagus and the jejunum. It has been necessary to build a short skin tube to bridge this gap. At the time this operation was performed I was not familiar with the work of Roux, published in the *Semaine Medicale* in 1907. Roux suggested a similar mobilization of the jejunum but placed the free loop in a subcutaneous tunnel. In the June number of *Surgery, Gynecology and Obstetrics,* Serge Yudin of Russia gives an excellent review of the literature and reports several patients operated upon by various methods including that of Roux. It should be noted that Roux and Yudin deal exclusively with corrosive stricture of the esophagus. This is not the lesion of the esophagus with which American surgeons are most frequently called upon to deal. Carcinoma of this organ is far more frequently encountered in this country. The technique employed by Roux, and later Yudin, is not applicable to the treatment of carcinoma, for they leave the thoracic esophagus in situ after performing a lateral anastomosis between the cervical esophagus and the mobilized jejunum. In November, 1943, the mobilized jejunum was brought transthoracically to the level of the first left interspace and successfully anastomosed to the cervical esophagus. If possible it would seem desirable to use the jejunum to re-establish the continuity of the gastrointestinal tract rather than the stomach. The jejunum can be taken over greater distances with less tension. Conservation of all the immobilized esophagus proximal to a tumor is best accomplished by leaving this portion in its bed. Due to contraction of the organ following mobilization and exteriorization, the tube that is finally brought out to the skin in the neck is very much shortened. Further-

more, the latter procedure may prove quite hazardous. The advantages of an intrathoracic esophagojejunostomy, I believe, will be emphasized as our experience increases.

On the surgical service of the Johns Hopkins Hospital in the last year there have been two patients with long-standing lye stricture in whom carcinoma of the esophagus has developed. One was found at autopsy following perforation of a carcinomatous ulcer of the lower end of the esophagus into the peritoneal cavity. This patient had been fed by means of a gastrostomy for thirty years. The second case represented an instance in which a carcinomatous ulcer of the upper portion of the thoracic esophagus perforated into a primary bronchus. The patient had a complete stenosis of the esophageal lumen due to a lye stricture of over thirty years' duration. As in the first case he had been fed by means of a gastrostomy for all but the first two or three years of his life. Carcinomatous change was proved in this instance by biopsy. These are the first cases which have come to our attention in which a malignant change has occurred in a benign stricture of the esophagus.

DR. CLARENCE BIRD, Chickasha, Okla.—Study of case reports and a review of hospital records show that in a large proportion of patients who are operated upon for esophageal lesions, the time interval between the onset of symptoms and the date of operation is excessive. On the basis of results obtained before 1937, one could not strongly encourage internists and general practitioners to bring patients with malignant esophageal lesions to operation, but more recently there has been considerable success in handling this type of lesion. It seems probable that the active and associate members of this organization, by encouraging early and repeated use of special diagnostic procedures and by encouraging earlier operations, can increase the percentage of operability in malignancy of the esophagus.

I am not certain that Dr. Garlock mentioned the advisability of careful bronchoscopy previous to operation on malignant tumors of the middle third of the esophagus. Some patients who have no bronchial symptoms harbor lesions in the left main bronchus which become evident only at bronchoscopy and which indicate inoperability.

I should like, finally, to record a further case of resection, with gastroesophageal anastomosis, of a traumatic stricture of the lower portion of the esophagus. This resulted in complete relief in a girl 22 years old, who according to the history sustained a stricture after swallowing a foreign body at the age of 1 year.

DR. EDGAR W. DAVIS, Washington, D. C.—I have enjoyed these reports immensely this morning, and without making any attempt to enter in the discussion of them, I would suggest that all of us who are doing or attempting to do esophageal surgery read an English abstract in the *American Review of Soviet Medicine*, February, 1944. The original Russian article, as quoted by Dr. Rienhoff, by Yudin and Roen and Yurason bringing the work on esophageal surgery up to date can be found in Book One, Vol. III, Moscow, Medgiz, 1942. I think this is a most instructive article, and all of us who are interested in that type of surgery should certainly read it.

MAJOR EARLE B. KAY, Medical Corps, A.U.S.—My interest in this subject has been largely confined to the reconstruction of the esophagogastric continuity following resection of the esophagus for carcinoma by means of an intrathoracic anastomosis between the proximal end of the resected esophagus and a gastric tube made from the greater curvature of the stomach. This interest was stimulated primarily by the number of patients seen following a Torek operation who are miserable because of the inability to swallow.

The operation is done in two stages. The first stage consists of fashioning a large gastric tube from the greater curvature of the stomach similar to a Beck-Jianu gastrostomy. This tube is placed into a pneumothorax space in the chest through a small rent in the left diaphragm. The first stage allows abdominal exploration for

hepatic and glandular metastases, and an enterostomy for feeding purposes if so desired. At the second stage, done in one to two weeks, the carcinoma is resected and an esophagogastric anastomosis is performed between the proximal esophagus and the readily available gastric tube.

The one advantage in this procedure is that it allows surgical removal of carcinomas at a higher level in the esophagus with restoration of the esophagogastric continuity than could be obtained by the one-stage transpleural operation. Even though in rare instances the stomach has been brought as high as the arch of the aorta to allow anastomosis, the majority of patients with long-continued esophageal obstruction from carcinoma have a small stomach which prevents such a procedure.

A free jejunal tube can be employed in a similar manner if the stomach is found to be too small to fashion a gastric tube of adequate length. At the first stage a gastroenterostomy is performed between the stomach and a free jejunal tube. The free end of the jejunal tube is closed and placed within the chest during the first stage. The remainder of the operation is similar to this. Experimentally, it was found that more care must be exercised with jejunal tubes in order not to impair their blood supply than with gastric tubes.

If it is felt inadvisable to attempt intrathoracic anastomosis and an antethoracic subcutaneous Beck-Jianu gastrostomy tube is contemplated, considerably more distance can be obtained by resecting the lower costal cartilages and eliminating the necessity for the gastric tube to descend down and then over the costal arch. Further length can also be obtained by mobilizing the stomach at the esophagodiaphragmatic junction and bringing the stomach forward. If these suggestions are employed the gastric tube can easily reach the level of the neck. These procedures are largely based upon experimental observations and more work is necessary to determine whether or not they may become applicable.

DR. LEO ELOESSER, San Francisco, Calif.—I hesitate to prolong this long but profitable discussion. I should like merely to allude to one case of stricture of the esophagus that I treated a number of years ago through an open thoracotomy. The man was an ex-convict who had swallowed lye with suicidal intent, and he was sent to us by the otolaryngologists. He had been very effectually sounded, but no food got into his stomach. However, when I opened his abdomen I found that the sound had gone down retroperitoneally as far as the sacrum.

The sounding had been done for some months previous without very deleterious effects. In opening his chest, of course, I found a fistula. Proceeding from there I was able to get a large bougie up into his mouth. Also the hypertrophy of the lower segment was such as illustrated in Dr. Gurd's films of the gizzard. It was not too difficult to introduce a large bougie forcibly into his stomach from the upper esophageal segment.

It was easier, with the presence of this form of fistula, to re-establish continuity between his mouth and his stomach and gradually to dilate it. This man subsequently died because he pulled out the tube and we did not have him re-undergo the whole procedure.

DR. JOHN W. STRIEDER, Boston, Mass.—Relative to the causes of death in esophageal resection for carcinoma with primary esophagogastric anastomosis in the chest, I would like to mention briefly one experience which I had in a series of ten cases which I had an opportunity to follow completely. It also emphasizes the point which Colonel Bird made relative to the advisability of doing both esophagoscopy and bronchoscopy preoperatively. I believe this is an extremely important dual maneuver.

This patient, a woman aged 52 years, had a carcinoma of the esophagus discovered in a very early stage, 31 cm. from the superior alveolar ridge. The tumor itself

was so small that in mobilizing the esophagus, although there was a positive preoperative biopsy, it was very difficult to palpate the tumor in the esophagus.

The tumor was resected and anastomosis was made after the suggestion of Dr. Garlock, by pulling the proximal esophagus anterior to the arch of the aorta. It was obvious from the second postoperative day that she was not aerating the left lung. On bronchoscopy, to our dismay, we found the left stem bronchus was completely occluded by extrabronchial compression.

This obstruction was known not to be due to tumor because of our preoperative bronchoscopy, and the observation was confirmed on subsequent bronchoscopy two days later. Because she had difficulty raising secretions and because even moderately copious secretions were of considerable embarrassment, in view of the fact that she was not using her left lung, we performed a tracheotomy in order to aspirate these secretions frequently and easily.

She died on the ninth day, and at autopsy we found there had been a leak in the anastomosis with a small localized abscess, perhaps the size of a half dollar and twice its thickness, in relation to the anastomosis, at the level of the arch of the aorta and also in relation to the left main stem bronchus. There was no general empyema. The left main stem bronchus was not incorporated in the wall of the abscess, rather the compression apparently resulted from the contiguous edema and pressure of the abscess.

I hesitate to mention our total experience at the Boston City Hospital. We have had an opportunity to explore twenty carcinomas of the esophagus, ten of which were operable. We have had two operative survivals and one living patient, over a period of two years. By way of partial extenuation I may say that we have dealt largely with the derelicts that one sees in a large municipal institution, and we have taken on all comers even though the chances of recovery seemed small.

DR. RALPH ADAMS, Boston, Mass.—I wish to show three additional cases of benign tumors of the esophagus. Illustrations appear in the article published in this issue of the JOURNAL.*

(Slide 1.) This was a woman 41 years of age, with rasping breathing, increasing for two months with no difficulty in swallowing. The mass moved upward and downward with the act of swallowing. On a statistical basis, substernal goiter would be by far the most likely diagnosis. The only other likely one would be an esophageal wall tumor.

The nature of this mass was not apparent until the recurrent nerve was demonstrated to run anterior to the tumor. In the course of some 23,000 thyroid operations it had never been observed at the Lahey Clinic that the nerve ran anterior to a thyroid tumor. Further dissection was made posteriorly. Some longitudinal esophageal fibers were found and a fibroma of the esophagus was removed.

(Slide 2.) This patient had difficulty in swallowing, of seven years' duration, but increasing only in the six months before admission. I would like to call attention to the characteristics of a benign intestinal lumen tumor as first brought out so clearly in our part of the country by Dr. Richard Schatzki. The barium fits over the top of the tumor somewhat as a cap. Barium flows freely around it and with fluoroscopy we saw the only place it did not flow was where the tumor was attached.

Directly opposite the tumor itself the esophageal wall looks normal, and one need only compare this slide with the following one with the narrow, tortuous channel created by carcinoma to see how markedly they differ in appearance. The tumor was too low to be removed through the neck and too large to be removed endoscopically. Its peculiar location in the organ in which it arose and its benign nature presented some specific problems in removal, and yet one must remove such a tumor with maintenance of esophageal continuity or accept all the hazards,

*See page 383.

mutilations, and disappointments which will follow, either if infection occurs or if a resection is used as an alternative. Perhaps we overemphasized the minutia, but extreme attention was devoted to details of asepsis.

(Slide 3.) The tumor was delivered by a traction suture into a protected field, and the pedicle ligated. For two weeks before the operation we gave the patient sterile water by mouth, but gastrostomy feedings otherwise. That would seem important in reducing the likelihood of sepsis.

(Slide 4.) This is a photograph of the pedunculated fibroma. Its benign nature is apparent in the microscopic section.

(Slide 5.) The next case has both scientific and human interest. This was a patient who had suffered from difficulty in swallowing at intervals for three years. He attended a reception at which both liquid refreshments and oysters were served. While partaking he felt an "oyster" in his pharynx which would not go down. He tried to extract it and found to his amazement that he could not do so. He pushed it back down his throat and choked within a few minutes. He had respiratory difficulty followed by cyanosis. He recovered in a few days and was studied at the Massachusetts General Hospital. Dr. Churchill was going into service and referred him to us. The pedunculated polyp was removed from the esophagus with an electrocoagulating snare through a suspension laryngoscope.

DR. JOHN H. GARLOCK, New York, N. Y.—There are a few points I would like to talk about. I would like to emphasize what Dr. Sweet said about benign strictures of the esophagus. We feel that most of those should be operated upon if there is very little response to instrumentation.

We have had six cases of benign stricture of the lower esophagus, most of them, curiously enough, in a congenitally short esophagus. We have done the transthoracic resection with six recoveries.

In reply to Dr. Decker's remarks I might say that we ought to discard the Torek operation. I think it is a good cancer operation, but it is bad from the patients' standpoint. They don't like it, and a surgeon doesn't like it. Invariably he develops mechanical difficulties with the rubber tubes. The question of using the jejunum must be seriously considered, but in comparison with using the stomach, I think the stomach should win out, for a very good reason. There is a greater chance of impairment of circulation of the jejunum when brought to a high place under the skin or intrathoracically.

If there is interference of circulation or breakdown of the suture line, the patient will invariably die. I think there is less chance of that happening if one uses the stomach because of its greater blood supply and ability to stretch to great lengths. I am fully acquainted with the work of Dr. Kay with his transplantation of the greater curvature of the stomach into the chest as a first stage procedure for utilization at a later date for anastomosis to the stump of the esophagus in carcinoma of the middle third.

My objection to his procedure is that he does a big operation, preparing the tube, before he finds out whether the tumor is operable. In all our experience we have never seen a stomach, no matter how long the history of dysphagia, that could not be stretched to great lengths in the chest. I think the question of contraction of the stomach because of prolonged starvation due to carcinoma is based on cases that came many years ago to the autopsy table.

We have done bronchoscopy, Dr. Bird, routinely in all carcinomas of the esophagus. I think it was you who called our attention to the fact that tumors may infiltrate the left main bronchus, and if you find infiltration, that is a positive indication of inoperability.

MUSCLE-SPLITTING THORACOPLASTY

RUBIN M. LEWIS, M.D.
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THE problem of collapse therapy by removal of ribs has been well standardized over a period of years, and a number of requirements have been established for satisfactory collapse in the type of tuberculosis which can be treated by thoracoplasty.

Jerome Head[1] in an original article described partial stage thoracoplasty, and ten years later both Head[2] and Wangensteen[3] described methods for performing thoracoplasty with a relatively low shock factor, small wounds, and consequently smaller potential space for the development of infection. The soundness of this technique is impressive.

As all chest surgeons know, there has been some reluctance on the part of medical phthisiologists as well as patients to accept thoracoplasty except in far-advanced cases. Because of the severity of the classical type of thoracoplasty this prejudice was sometimes difficult to combat. The muscle-splitting type of thoracoplasty has done much to overcome this attitude in our own clinics. Postoperative shock is reduced and incidence of infection is lessened by reason of the smaller operative field; the cosmetic and functional factors are improved.

In addition to these factors, this type of operation requires less nursing care than does the classical type. The patient is able to feed and bathe himself the day following operation, and usually on the second day may even walk to the bathroom.

DISCUSSION

Our first muscle-splitting thoracoplasty was performed in 1939 on a Negro man 67 years of age, with a giant cavity in the left upper lobe. His general physical condition and his age did not warrant the full type of paravertebral thoracoplasty, and the muscle-splitting type of partial thoracoplasty suggested by Head was decided upon. Six ribs were removed and the cavity closed; at the time of this communication, the patient, 72 years old, is in sound health, has a negative sputum, and is carrying on as well as could be expected for a man of his age. In addition to the fact that the patient is living and has a negative sputum, he has ceased being a social hazard and no longer acts as a carrier of tuberculosis.

After a period of time, the muscle-splitting procedure was chosen as routine in mixed infection empyemas because of its inherent advantages: (1) The drainage tube which is placed at the ninth rib in the midaxillary or posterior axillary line is well away from the incisions in

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Read by title at the Twenty-fifth Annual Meeting of the American Association for Thoracic Surgery at Chicago, Ill., May 5 and 6, 1944.

the upper portion of the chest (in this way the upper stages can easily be done without the risk of infection from the drainage wound) and (2) The patients were so ill that a major type of thoracoplasty during their sickest period would be a hazard to life. The procedure is carried out after inserting a large drainage tube through the ninth rib by a partial costectomy, and then the four partial stages are completed at weekly intervals. Thus, the patient is brought to the final stage in fairly good condition at which time the tube is removed, the lower portion of the chest is opened with a large U incision, the seventh, eighth, and ninth ribs are removed, and a partial pleurectomy is performed. Since this method causes much less shock to the patient than the old type Schede thoracoplasty, the operative hazard is definitely reduced.

Dr. Charles P. Bailey, Dr. Frederick D. Stubbs, who are members of my staff in Thoracic Surgery in the Division of Tuberculosis at the Philadelphia General Hospital, and I have adopted this procedure in other hospitals where we work. In the hospital, the grapevine has all the patients informed about the "new operation." The fear of the big operation has been dissipated and the bugaboo of a big scar and loss of arm and shoulder function appreciably decreased. As most of the incisions are made along skin cleavage lines, the scars become almost invisible. The muscles are left intact, and as a result arm and shoulder function is preserved unimpaired. It has been interesting to see the change in the attitude of the patients and the medical phthisiologists to this procedure.

The resumption of shoulder function during wound healing as practiced after the classical thoracoplasty has been discontinued. Instead we have asked patients to keep the arm at rest so that new bone could be formed in the periosteal beds with maximum collapse. After about ten to fourteen weeks resumption of exercise usually results in excellent shoulder function.

TECHNIQUE

Jerome Head's technique of operation has been adopted. The only material difference is the incision for the second anterior stage. Here the incision is made below and on the line of the pectoral fold. This affords ample operative exposure for the fourth, fifth, and sixth ribs, and in women, it is lateral to the breast.

In addition to this slight deviation in technique we have found definite advantage in the use of a periosteal elevator of my own design (Fig. 1), which was added to our armamentarium in 1937. With it, we have been able to do all forms of thoracoplasty including the muscle-splitting type. Periosteal stripping is done with unusual facility. The narrow scapulatractor (Fig. 2), one of several in varying widths which were designed for the major type thoracoplasty, serves to retract the chest wall structures while the rib is being freed of its periosteum.

It is to be noted that the elevator has a broad end which is used for incising and separating the periosteum from the face of the rib. When

the long axis of the elevator is parallel to the rib, the angle between the leading face of the blade and the rib is an acute angle, thus tending to lift the periosteum from the rib as the instrument is pushed forward. When the elevator is drawn back, the handle is tilted upward, the follower face of the blade becomes the lead face, the angle again becomes an acute angle, and the separation of periosteum from rib is continued.

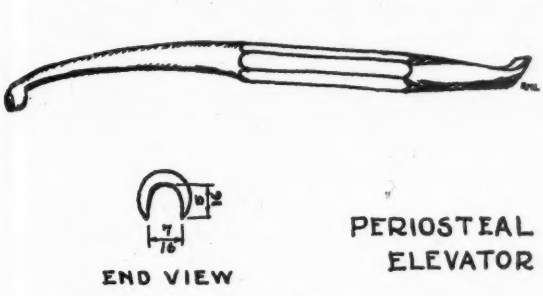

Fig. 1.

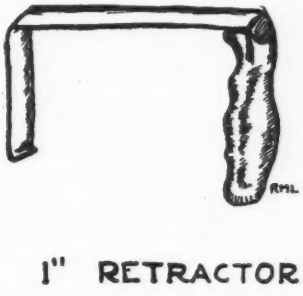

Fig. 2.

Fig. 1.—Periosteal elevator-raspatory. An all-purpose elevator and raspatory for thoracic surgery. The hook end is designed to clean one-half of the rib in one direction, and the other half on the return stroke. The hook is at the end of a long handle with a thoracic curve and so designed to pass from one border to the other under the muscle planes without removing or changing ends or instruments. The scraper end is designed so that a periosteal flap is raised as a chip.

Fig. 2.—Retractor for elevating chest wall structures, while rib is being freed of its periosteum.

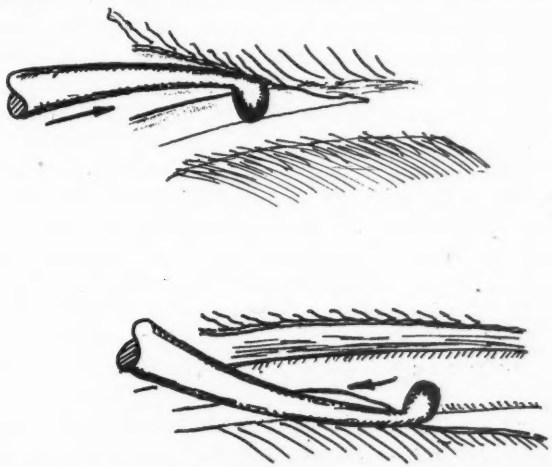

Fig. 3.—Showing the use of the hook end of the elevator, stripping off the intercostal muscles on the upper and lower surfaces of a rib. The instrument is turned from the upper to the lower surface after the periosteum has been stripped far enough along the rib length.

The opposite end of the elevator is attached to a long curved handle which allows the instrument to be forced well around the thorax. The end is U shaped and, when the instrument is kept close to the rib, it slides along the rib edge beneath the muscle planes without much

resistance, and can be turned to the other edge to repeat the stripping in the opposite direction. In this way, the periosteum and intercostal muscles are easily and cleanly freed from the rib (Fig. 3).

CASE REPORTS

Our first use of this method was in the Negro man described previously, and in twenty-one patients operated upon since 1942, in seventy-nine stages, we had no wound infections and two deaths in the series. One death was that of a patient who had had a previous extrapleural-intrapleural pneumonolysis which failed to close the cavity. He had bilateral disease, and while we were reluctant to proceed with thoracoplasty it was felt that operation might prove of some value. His death was from disease spread after the final stage.

The other patient also developed a pneumonic spread and was too sick at any time to withstand more than the upper posterior stage which consisted of removing posterior segments of the upper three ribs. He died eight months after operation and was at no time in condition to have a continuation of his surgery.

SUMMARY

Generally speaking, patients withstand the muscle-splitting type of operation well in mixed infection empyemas. In cases with cavernous disease, we feel that the results are even more encouraging. The blood pressure and the pulse rates remain almost constant during the entire operation, and in many cases the pulse rate actually slows during the operation. It has not been necessary to use intravenous solutions, plasma or blood, as was so often necessary in our experience with the classical type of thoracoplasty.

The muscle-splitting type of thoracoplasty has been adopted as a routine procedure in our clinic at the Philadelphia General Hospital. We feel that the results so far have been gratifying. While our series is too small for sound comparison, we believe that the risk to the patient's life and the incidence and severity of wound infections are lessened. Selective collapse in muscle-splitting thoracoplasty is generally more complete as entire rib lengths are easily removed, and apicolysis may be done without any more difficulty than in the classical type.

The cosmetic results are definitely better than in those cases where the large parascapular incision is made, and in our opinion the muscle function of the arm and shoulder is better. As a result, patients are less hesitant to undergo thoracoplasty. We feel that this is important to the individual and to society.

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POSTLOBECTOMY LOBAR COLLAPSE

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OVER the whole period that lobectomies have been performed in treatment of bronchiectasis, postoperative collapse of the remaining lobe on the same side has been a perpetual stumbling block in the path of good results. In this communication the etiology of the condition is discussed and a method of treatment is suggested which has proved successful in practice. The evil effects of the condition may be briefly summarized under three headings:

1. Increase in mortality. This may follow the massive consolidation and infection of the remaining lobe or it may be the outcome of total pyothorax produced by the collapse. Gowar,[1] in an extensive study of this subject in 1939, found that one-third of the total operative mortality could be attributed to collapse.

2. Prolongation of convalescence.

3. A cause of bad final results. This is due to the development of bronchiectasis in the remaining lobe, and can readily be explained if one accepts the theory of the cause of bronchiectasis which was strongly supported by Davidson and Lander.[2] They maintained that the bronchial dilatation was due to the more direct application to the bronchial walls of the intrapleural pressure which is made possible when the surrounding pulmonary tissue is collapsed. Undoubted support was given to this view by a case recently seen by us. The patient three years previously had had a left lower lobectomy performed by another surgeon and before this operation bronchograms had shown the left upper lobe to be normal. The radiographic appearance of massive collapse of the left upper lobe gradually gave place to the typical picture of cystic bronchiectasis.

In considering the general postoperative course, Gowar as well as other authorities refer to re-expansion occurring gradually over the first twenty-four hours, but in our experience the remaining upper lobe should fill the apex or the lower lobe fill the base of the chest before the patient leaves the theater, and breath sounds should be readily heard in the appropriate area. There may, of course, be a vacant

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†Recently surgeon to E.M.S. Chest Unit.
Being the substance of a paper read by one of us [J. L. C.] at a meeting of the Moynihan Chirugical Club in Birmingham, Eng., September, 1943.
Received for publication May 12, 1944.

cavity at the base from which the bronchiectatic lobe has been removed and this may not be completely obliterated for several days or weeks. This complete expansion of the remaining lobe should always be immediately possible providing the airway is cleared by the cooperation of an expert anesthetist. In spite of this our figures show that the incidence of collapse in our cases has been the same as in the 154 cases of Tudor Edwards and Price Thomas in which Gowar found collapse to have occurred fifty-one times.

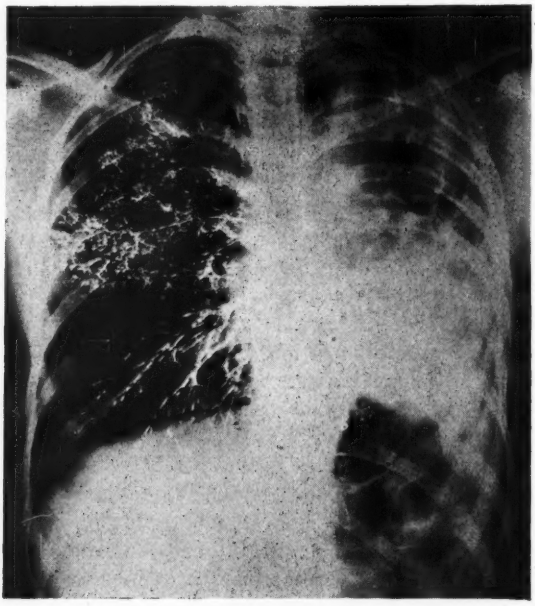

Fig. 1.—Roentgenogram showing cystic bronchiectasis which developed in the upper lobe following left lower lobectomy.

This secondary collapse has been attributed to several factors. Reflex bronchial spasm has been blamed, although the experiments of Band and Hall[3] failed to support this. Belsey[4] considered that swelling of the mucosa as a result of a recent bronchogram was a factor, while Tudor Edwards has expressed to us his view that inflammatory swelling around the stump is the cause of at least the more delayed cases. Many people have been struck by the better postoperative progress of patients whose pleural cavities were obliterated by adhesions. This has been explained by the retention of a certain amount of air in the remaining lobe so that it will be easier to cough the material out of the bronchi. This view led Bethune[5] to introduce his method of pleural poudrage. This method has been employed by us but as will be seen from our figures no reduction in the incidence of collapse was

produced in the twenty-seven cases in which satisfactory pleural symphysis was obtained. We may state here that in spite of this we do still consider that pleural symphysis is an advantage and makes for easier convalescence and for easier treatment of collapse should it occur. It is felt that it is for these reasons rather than for its direct effect on preventing collapse that such authorities as Robinson,[6] Graham,[7] and Tudor Edwards[8] first noticed the more satisfactory course in patients whose pleural spaces were obliterated.

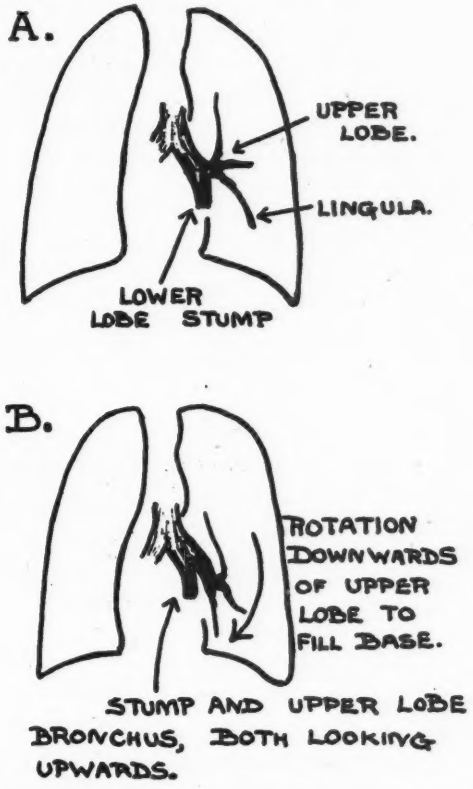

Fig. 2.—*A* represents the condition immediately after the lower lobe was removed. *B* shows what happened when the upper lobe expanded in an effort to fill the whole left side of the chest. The upper lobe bronchus rotated downward and came almost into line with the stump of the lower lobe.

In view of the unsatisfactory preventive measures previously employed and a strong feeling that patients develop collapse following a period of inability to cough effectively, it was decided to use bronchoscopy on all such patients immediately when the complication occurred. This procedure, which has been used over the past year, has proved most valuable therapeutically and has demonstrated some interesting

facts about the etiology of the condition. First it is noted that not a single patient was seen in which the collapse was attributed to hilar swelling. Second, the collapse always appeared to be due to obstruction with sputum; third, when this sputum was removed re-expansion could be immediately obtained; and fourth, it was noted in all cases of lower lobe lobectomy that the upper lobe bronchus instead of coming off obliquely was looking almost directly upward. This means that it is nearly parallel with the stump of the lower lobe.

These findings have led us to believe that the course of events is as follows: The initial expansion of the upper lobe carries its bronchus downward in an effort to fill the cavity produced by the removal of the lower lobe. This brings the upper lobe bronchus almost parallel to the stump. During the first postoperative days pus collects in the stump from which it is difficult to be coughed up as there is no air behind to drive it out. If the stump fills it may easily spill over and block the upper lobe. It may still be coughed up, but, if the patient is not prepared to put up with the necessary pain, collapse will result. The symptoms will depend on the extent to which the smaller bronchi and bronchioles are filled and how grossly the obstructing material is infected. The deeper the pus gets into the lung the more permanent the condition will be. Among the various aspects of the case which this theory explains is the fact that collapse is more common on the left

TABLE I

INCIDENCE OF POSTLOBECTOMY COLLAPSE (12 IN 33 CASES OR 36 PER CENT)*

			PER CENT
Onset:	From operation	1	8
	2nd to 5th day	9	75
	6th to 8th	1	8
	After 8th day	0	
	One case, exact time uncertain, during first 3 days	1	8
Side of operation:	Right	2 in 7	28
	Left	10 in 26	40
Lobes removed:	L.L.L.	2 in 13	15
	L.L.L. & lingula	8 in 13	62
	R.M.L.	0 in 2	—
	R.U.L.	0 in 1	—
	R.M.L. + R.L.L.	2 in 4	50
Age:	Under 16	5 in 8	70
	16 to 30	7 in 18	38
	Over 30	0 in 7	—
Amount of sputum:	Under 5 oz.	9 in 22	41
	Over 5 oz.	3 in 11	27
Drained:	Present	7 in 19	35
	Undrained	5 in 14	36
Adhesions:	Present	10 in 27	36
	Absent	2 in 6	33
Sex:	Males	5 in 19	20
	Females	7 in 14	50

*This small series was used as all the patients have received similar preoperative and postoperative care. Twenty-seven lobectomies were performed in the last 12 months.

than on the right side (17.5 to 42.5 per cent in Gowar's Brompton Hospital series). The left upper lobe bronchus normally comes off more obliquely than its opposite number on the right and thus after a left lower lobectomy the left upper lobe bronchus more easily comes into a parallel position to the stump than does the right upper lobe bronchus. This fact can easily be confirmed on bronchoscopy of these patients.

In practice it was found that only one bronchoscopy was required in adults, although recollapse may occur in children necessitating further instrumentation. It was found that even on the first or second postoperative day these patients stood bronchoscopy without being upset, in fact many felt immediately better. The procedure was always done in the theater under local anesthetic. By laying the patient on the good side the bronchoscope can be introduced through the side of the mouth into the affected lung with remarkable ease. In fact, it is our experience that it is easier to use the bronchoscope on these patients than on the usual run of patients. This is thought to be due to the greater ease with which they can relax.

TABLE II

TREATMENT AND RESULTS

CASE	ONSET (DAY)	BRONCHOSCOPY	IMMEDIATE RESULT	AGE (YR.)	FINAL RESULT
1	5th	+	Expanded	21	Good
2	6th	+	Collapsed until 10th day	7	Good
3	3rd	+ × 2	Expanded	14	Good
4	?	+	Collapsed until 5th week	6	Good
5	1st	+ × 3	Expanded	14	Good
6	2nd	+	Expanded	21	Good
7	4th	+	Expanded	23	Good
8	3rd	+	Expanded	31	Good
9	8th	+	Expanded	20	Good
10	5th	–	Collapsed until 9th week	18	Died, C.A.
11	3rd	–	Collapsed until 5th week	9	Good
12	4th	–	Collapsed until 12th day	21	Good

An interesting point arose in an early case in which drainage was not carried out. The patient developed collapse that was thought to be due to the presence of fluid in the pleural cavity. Aspiration of 13 ounces resulted in only the slightest improvement in the radiographic appearance and it was realized that this had been a dangerous move since the increase in intrapleural pressure with the bronchus plugged with pus would only tend to draw that pus further into the smaller bronchi. Bronchoscopy was therefore immediately used after which, with the bronchi clear, a further aspiration resulted in complete re-expansion. The same situation has since occurred in another case but here bronchoscopy was immediately undertaken.

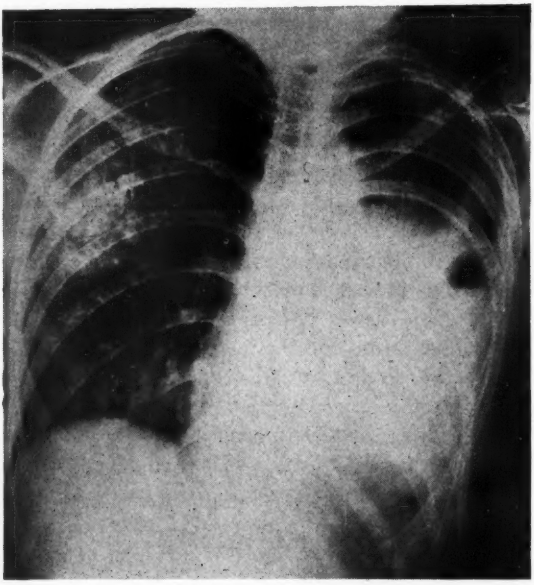

Fig. 3.—Radiogram of patient in whom drainage was not carried out. The left upper lobe is collapsed with some fluid and air in the pleural space.

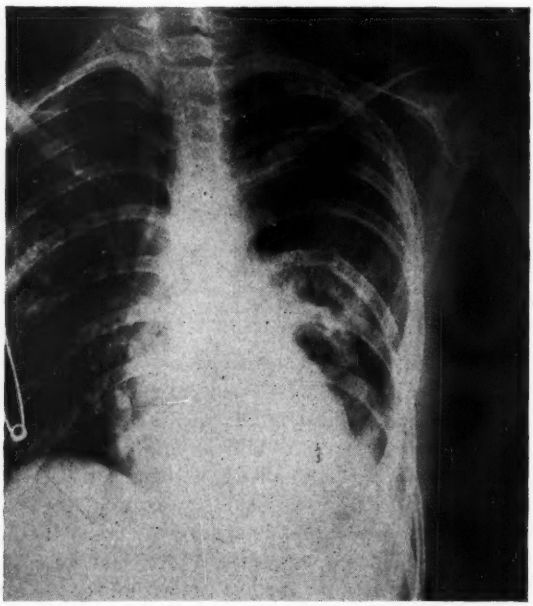

Fig. 4.—Radiogram of same patient and made same day as Fig. 3. Bronchoscopy was performed followed immediately by aspiration of the chest, and complete re-expansion of the left upper lobe was obtained.

These findings with regard to the part played by the material collecting in the hilar stump have led naturally to methods being adopted to prevent collapse by keeping this stump dry. It appeared that this should be possible if early postural drainage was employed by laying the patient over on his good side. It is too early to speak dogmatically about this method but one word of warning may be of assistance. It has been found that such posturing if employed between the seventh and twenty-first days is likely to precipitate a bronchial fistula; however, it would appear that posturing between the second and fifth days is without danger and gives hopeful signs of being useful. It is to be noted that in our series 75 per cent of the cases of lobar collapse occurred in this period between the second and the fifth day. This postural treatment is made much easier in view of the fact that drainage is usually not carried out in our cases.

SUMMARY

1. From several aspects postlobectomy lobar collapse is a serious complication.

2. It is due to the obstruction of the bronchi with pus in association with certain mechanical alterations in the shape of the bronchial tree after lobectomy.

3. The longer this pus is left plugging the bronchi, the deeper it will pass into the lung and the more permanent will be the condition.

4. Once collapse occurs it should be treated immediately by bronchoscopic aspiration, the results of which are highly satisfactory.

5. Postural measures give rise to some hope of reducing the incidence of the condition.

We wish to thank Mr. W. J. Pardoe of the Anatomy Department of the Birmingham University for his excellent photographic work which was made possible by the courtesy of Dr. C. F. V. Smout, acting professor.

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FLAP VALVE CONSTRUCTED FROM A MEDICINE DROPPER

ESKE WINDSBERG, M.D.
PROVIDENCE, R. I.

A ONE-WAY flap valve can be constructed easily from the rubber bulb of the ordinary medicine dropper. The closed end of the bulb is cut with scissors to form a fish mouth. This makes a vent through which air under pressure will travel one way only. A bulb syringe attached to the normally open end of the medicine dropper bulb can be made to demonstrate this fact (Fig. 1, *A* and *B*).

When the rubber bulb at hand is rather thick or hard, a large fish mouth is required. Conversely, when the rubber is thin and soft, a smaller fish mouth will work better. An elastic band may be placed around the bulb at the base of the fish mouth to regulate the force required to open the vent, and to insure its closure.

The application of this bulb valve is as simple as its construction. Through the medium of the glass part of the dropper it is attached to the end of the intrapleural catheter. (The bottleneck end of the glass part should be cut away.)

At the termination of an operation the flap valve is attached to the chest catheter and at once incorporated into the wound dressings. Except in unusual circumstances such as hemorrhage, it needs no further care or even inspection for at least twenty-four hours. The patient is protected against excessive intrathoracic pressure, and expansion of the remaining lobes is automatically promoted. Should a leak occur in a bronchial stump, the vent will function automatically to protect the patient. Liquid drainage, free from clots and fibrin, will also come through.

The intrathoracic status can be tested by unhooking the flap valve and attaching a bulb syringe. Usually this is not required until the day after operation. The advisability of continuing the use of the valve in the dressing, of using an extension tubing and placing the valve at the end into a bottle, or of discontinuing the use of the valve can then be determined. If excess negative pressure is feared, a mercury safety vent can be incorporated into the system.

I have found this simple device handy and useful on many occasions following lobectomy and pneumonectomy. It is being used routinely, incorporated in the original dressing in the operating room. This enables safe handling and transfer of the patient to his bed. It pre-

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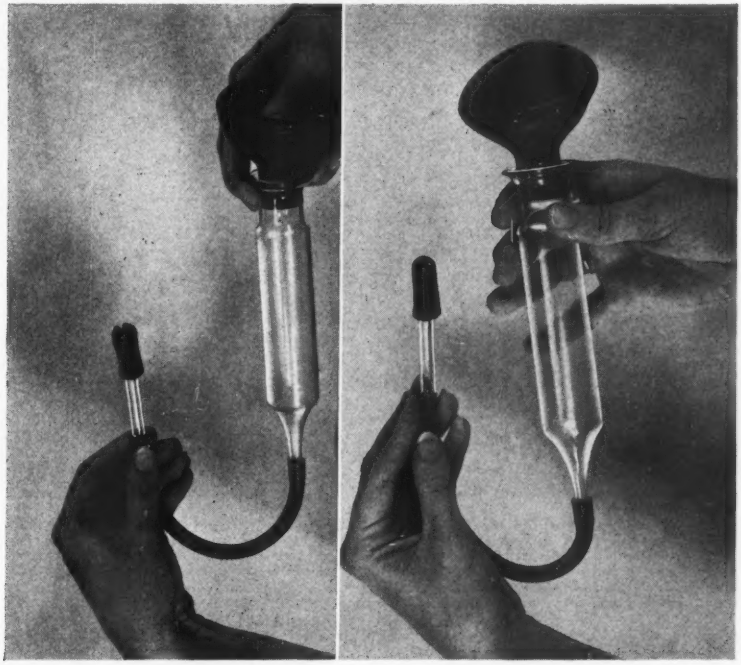
Received for publication May 31, 1944.

vents any sudden increase in intrapleural pressure during this critical interval and removes chance extraction of the newly placed chest catheter. For patients in whom drainage is a primary necessity, especially in the presence of fibrin, it is usually not to be employed, since it will not work. However, during the first day or two following the drainage of a massive empyema, the device on occasion has proved desirable in conjunction with underwater drainage. Its use here minimizes the mediastinal shift due to respiration.



A. *B.*

Fig. 1.—*A*, Pressure being applied forcing air out through fish mouth of rubber bulb. *B*, Rubber of bulb syringe remains collapsed with fish mouth closed preventing any air from returning to system after thumb pressure has been removed.

The described device is superior to the finger-cot or to the finger part of a rubber glove into which a fish mouth is cut. Not every finger-cot preparation will work, and one which is found to work at the outset cannot always be depended upon to work continuously. The finger-cot preparation works well only when hanging freely in an open bottle, out of water. The bulb fish mouth functions equally as well under water as it does above water. Simple underwater drainage may allow wide shifting of the mediastinum during respiration or coughing.

The outstanding feature of the bulb fish mouth preparation is that it also works well when incorporated into the chest wall dressings. This

obviates the need for specialized attention. The rapid changes now encountered in nursing and interne personnel emphasize this as an important consideration. This is especially true during the first twenty-four to seventy-two hours of postoperative care when the patient requires so many other attentions, such as oxygen therapy, tracheal suction, intravenous fluids, and occasionally transnasal gastric suction (Fig. 2).

Fig. 2.—Photograph of man, J. C., aged 59 years (Hospital No. 380386, Rhode Island Hospital), six days following total pneumonectomy of left lung for bronchiogenic carcinoma. Line on adhesive of dressing shows location of thoracic incision. Intercostal catheter enters the chest just posteriorly to lateral angle of wound.

Medicine dropper bulb fish mouth preparation is shown on end of catheter incorporated in dressings of chest wall. Dressing is partly reflected to show the valve.

Note intravenous setup and intranasal catheter for oxygen. During the second twenty-four hours following operation this patient also had an indwelling catheter for decompression of gastric dilatation.

Thoracic injuries in the Armed Services often require immediate pleural decompression. The device may be attached to the hilt of a needle entering the chest and fixed in place with a dressing. This will allow safe transport, often under trying conditions. For military casualties having closed drainage and requiring rapid evacuation, especially by air, the device incorporated in the dressings may be found to be time- and laborsaving and often indispensable.